

**Posters as a passive intervention to reduce electricity and water consumption in the University of Pretoria's Groenkloof residences**

by

**Lindokuhle Benjamin Matsebula**

Treatise submitted in partial fulfilment of the requirements for the degree of

**Masters of Science (Real Estate)**

in the Faculty of Engineering, Built Environment and Information Technology  
University of Pretoria

12 January 2018

## **Declaration**

I, the undersigned, hereby confirmed that the attached treatise is my own work and that any sources are adequately acknowledged in the text and listed in the bibliography.

I accept the rules of the University of Pretoria and the consequences of transgressing them.

This treatise is submitted in partial fulfilment of the requirements for the degree of MSc Real Estate at the University of Pretoria. It has not been submitted before for any other degree or examination at any other University.

-----  
Signature of acceptance and confirmation

Lindokuhle Benjamin Matsebula

12 January 2018

## **Abstract**

Potable water is a relatively scarce natural resource. This scarcity is evident on a global scale. For humankind potable water is not only needed to sustain life, but also to engage in activities that maintain and enhance its own comfort and quality of life. These activities contribute to the degradation of water quality and exacerbating water scarcity. Electricity is a resource that needs to be generated, and is used significantly to also maintain and enhance human comfort, and quality of life. The generation of electricity produces a significant amount of greenhouse gases, gases that contribute to climate change. The use of both resources needs to be more ecologically sustainable to reduce the negative impact caused. Wherever possible, the use of these resources should be reduced.

University residences utilise substantial amounts of water and electricity. This is because they are commonly designed to accommodate a large number of students. Implementing a behaviour change intervention in a residence therefore has the potential for greater ecological impact if the intervention is successful, due to the large number of people.

There are different types of interventions aimed at changing behaviour, with some being active and others passive. Being active or passive is determined by whether or not direct interaction with the subject is required to achieve the desired change. Information provision can be a passive intervention by using posters and pamphlets. It can also be active by using Q&A sessions and lectures. The study aimed to determine if the use of a passive behaviour change intervention could result in the reduction of water and electricity consumption in university residences. The passive intervention utilised was prompting in the form of posters.

A quasi-experimental design with a mixed methods approach was employed. Quantitative data were meter readings for both electricity and water, while qualitative data were obtained from focus groups. 3 female residences at the University of Pretoria's Groenkloof campus were used in this study. Posters were placed at the points of decision in two of the residences. The third female residence was monitored as the control and no posters were put up in it. Monthly water and electricity meter readings were used to determine if this change had occurred. Focus groups were conducted to understand from the subjects how the intervention had affected them, if at all.

Results from this study indicated that water and electricity consumption was reduced, with some reductions being statistically significant and others not. The study, however, cannot confidently predict that the intervention was successful due to various limitations.

*Keywords:* behaviour change, water consumption, electricity consumption, passive intervention, visual prompts

## **Acknowledgements**

First and foremost, many thanks to God Almighty. I end here, as I would not be able to articulate my gratitude and appreciation for everything I have received.

Thank you to the Mandela Rhodes Foundation, who funded my studies and allowed me to 'aspire to be'.

Thank you to my research supervisor, Prof Chrisna du Plessis, who put up with my disappearances, occasional disillusionment and provided invaluable guidance and mentorship.

Thank you to Mr Corné Slabbert, from the Department of Facilities Management, who albeit a very busy schedule, tolerated me dropping by for meter readings.

Thank you to Dr Jacques du Toit, from the Department of Town and Regional Planning, whose interview and research encouraged me on my journey of interdisciplinary research.

Many thanks to family and friends, too many to list without forgetting some, who helped with expenses, putting up posters, supported me, proofread my work and just were there through it all: ngiyabonga kakhulu.

# Table of Contents

<b>CHAPTER 1 - Introduction to the study .....</b>	<b>11</b>
1.1. Introduction.....	11
<b>CHAPTER 2 - Literature survey.....</b>	<b>13</b>
2.1. Introduction.....	13
2.2. Homo sapiens: development at all costs? .....	13
2.2.1. Consumerism .....	14
2.2.2. Development on Earth: a system with limits and the need for adaptation .....	16
2.2.3. Development must meet needs.....	18
2.3. Global need for energy.....	20
2.3.1. From fire to electricity .....	21
2.3.2. Producing electricity .....	22
2.3.3. The real cost of energy.....	23
2.3.4. Conclusion.....	24
2.4. Energy demand of South Africa .....	24
2.4.1. South Africa's demand and supply of electricity.....	25
2.4.2. Domestic energy use in South Africa and the need for behaviour change .....	29
2.4.3. Conclusion.....	30
2.5. The global need for water .....	30
2.5.1. Food security and the looming three-pronged crisis .....	30
2.5.2. Potable water scarcity, access to water and climate change.....	31
2.5.3. Human health and water pollution.....	33
2.5.4. Conclusion.....	34
2.6. Water demand of South Africa.....	34
2.7. Defining and understanding attitude .....	35
2.8. Defining behaviour .....	38
2.9. Behaviour modification.....	39
2.10. Attitude-behaviour relationship .....	41
2.10.1. Theory of Reasoned Action and Theory of Planned Behaviour.....	41
2.11. Behaviour change strategies: intervention design and implementation .....	44
2.11.1. Curtailment versus efficiency behaviours.....	44
2.11.2. Intervention classifications .....	45
2.11.3. Informational strategies .....	46
2.11.4. Combining interventions.....	47
2.11.5. Designing and placing prompts.....	48
2.12. Conclusion.....	48
<b>CHAPTER 3 - Research design and methodology .....</b>	<b>50</b>
3.1. Introduction.....	50
3.2. Problem statement and research question .....	50

3.2.1.	Problem statement .....	50
3.2.2.	Research question.....	50
3.3.	Research Strategy .....	50
3.4.	Methodology.....	51
3.4.1.	Poster design and placement.....	51
3.4.2.	Data collection .....	54
3.4.3.	Data analysis .....	54
3.5.	Sampling .....	55
3.6.	Assumptions, limitations and delimitations .....	55
3.6.1.	Assumptions .....	55
3.6.2.	Limitations .....	56
3.6.3.	Delimitations .....	56
3.7.	Conclusion.....	57
<b>CHAPTER 4 - Results</b>	<b>.....</b>	<b>58</b>
4.1.	Introduction.....	58
4.2.	Tabulated meter readings of electricity and water consumption.....	58
4.2.1.	Electricity meter readings .....	58
4.2.2.	Water meter readings .....	60
4.3.	Graphic representation of electricity and water consumption .....	61
4.3.1.	Comparison of residences against each other .....	61
4.3.2.	Comparison of month-on-month readings for each residence .....	65
4.4.	Statistical analysis .....	68
4.4.1.	Electrical consumption .....	68
4.4.2.	Water consumption.....	70
4.5.	Focus group responses.....	72
4.5.1.	Inca focus group .....	72
4.5.2.	Lilium focus group .....	73
4.5.3.	Zinnia focus group .....	75
4.6.	Discussion .....	76
4.7.	Conclusion.....	77
<b>CHAPTER 5 - Conclusions and recommendations</b>	<b>.....</b>	<b>79</b>
5.1.	Introduction.....	79
5.2.	Revisiting the sub-research questions .....	79
5.2.1.	Sub-question 1: What is behaviour change and what interventions exist to bring about behaviour change? .....	79
5.2.2.	Sub-question 2: Did the passive intervention reduce water and electricity consumption in the residences? .....	80
5.3.	Recommendations .....	81
<b>LIST OF References</b>	<b>.....</b>	<b>83</b>

**Appendices ..... 91**

# List of Figures

- Figure 1: Earth at night .....22
- Figure 2: Attitude structure views .....38
- Figure 3: Model of the Theory of Reasoned Action .....42
- Figure 4: Model of the Theory of Planned Behaviour .....43
- Figure 5: Examples of in-situ placement of posters .....53
- Figure 6: Electricity consumption in the three female residences in 2014 .....61
- Figure 7: Water consumption in the three female residences in 2014.....62
- Figure 8: Electricity consumption in the three female residences in 2015 .....63
- Figure 9: Water consumption in the three female residences in 2015.....63
- Figure 10: Electricity consumption in the three female residences in 2016 .....64
- Figure 11: Water consumption in the three female residences in 2016.....64
- Figure 12: Electricity consumption in Zinnia for 2014, 2015 and 2016 (arrow indicates when posters were put up).....65
- Figure 13: Water consumption in Zinnia for 2014, 2015 and 2016 (arrow indicates when posters were put up) .....66
- Figure 14: Electricity consumption in Inca for 2014, 2015 and 2016 (arrow indicates when posters were put up).....66
- Figure 15: Water consumption in Inca for 2014, 2015 and 2016 (arrow indicates when posters were put up) .....67
- Figure 16: Electricity consumption in Lilium for 2014, 2015 and 2016 (arrow indicates when posters were put up).....67
- Figure 17: Water consumption in Lilium for 2014, 2015 and 2016(arrow indicates when posters were put up) .....68

**List of Tables**

Table 1: Monthly electricity usage for 2014 (in kWh) .....58

Table 2: Monthly electricity usage for 2015 (in kWh) .....59

Table 3: Monthly electricity usage for 2016 (in kWh) .....59

Table 4: Monthly water usage for 2014 (in m<sup>3</sup>) .....60

Table 5: Monthly water usage for 2015 (in m<sup>3</sup>) .....60

Table 6: Monthly water usage for 2016 (in m<sup>3</sup>) .....61

Table 7: Descriptive statistics for electricity consumption readings .....68

Table 8: Inferential statistics for electricity consumption readings .....69

Table 9: Descriptive statistics for water consumption readings .....70

Table 10: Inferential statistics for water consumption readings .....71

## List of Acronyms/Definitions/Abbreviations

### Acronyms

ESKOM Electricity Supply Commission

### Definitions

Active intervention An intervention that requires interaction with the subject for it to be implemented. Examples are goal setting, commitment and information provision in the form of lectures or Q&A sessions.

Electricity consumption Electricity use

Energy consumption Energy use

Passive intervention An intervention that requires no interaction with the subject for it to be implemented. Examples are prompting, feedback and information provision in the form of posters and pamphlets.

Residence Student accommodation as provided by a university. This can be considered synonymous with 'university dormitory'.

Water consumption Water use

### Abbreviations

MDGs Millennium Development Goals

TRA Theory of Reason Action

TRB Theory of Planned Behaviour

WCED World Commission on Education and Development

# CHAPTER 1 - INTRODUCTION TO THE STUDY

## 1.1. Introduction

There is a significant amount of empirical evidence (Intergovernmental Panel on Climate Change, 2011; Intergovernmental Panel on Climate Change, 2013; Rockström, Steffan, Noone, Persson, Chapin, Lambin, Lenton, Scheffer, Folke, Schellnhuber, Nykvist, de Wit, Hughes, van der Leeuw, Rodhe, Sörlin, Snyder, Costanza, Svedin, Falkernmark, Kalberg, Corell, Fabry, Hansen, Walker, Liverman, Richardson, Crutzen & Foley, 2009a) supporting the idea that we are facing ecological crises springing up from various fronts. These crises in turn produce existential concerns to humankind and the flora and fauna with which we share this planet. The fact is these are global concerns that we either create or perpetuate due our lifestyles. Many of the most potent causes are from behaviours, industries and business models that we pursue.

There are more than 7 billion people on Earth (United Nations, 2015), each taking from and giving to the natural and/or built environment around them. We therefore have a responsibility to support the development today and the development tomorrow of humankind, while ensuring the survival of the flora and fauna around us as well. We need to remember that we are not owners of the Earth, but stewards for future generations (Chapin, Power, Pickett, Freitag, Reynolds, Jackson, Lodge, Duke, Collins, Power & Bartuska, 2011; Omoogun, Egboniyi & Onnoghen, 2016; Weiss, 1992). We can bring about great change if we change our behaviour in two areas: energy and water use.

Potable water is a relatively scarce natural resource, which we use to meet physiological and many other needs. Energy powers our lives, allowing us to do more, go further and experience better comfort. The current consumption patterns of these two resources produce catastrophic environmental implications. We cannot wait for governments and big corporations to change their stance concerning environmental degradation before things change. Each individual can do something in their sphere of influence to mitigate the problems we face.

This study is aimed at determining if posters as prompts could be an effective behaviour change intervention that would result in the reduction of water and electricity consumption. It is targeting university students staying in university residences. It assumes that if future professionals can adopt an ecologically sustainable worldview today, they will carry this ethos into their future places of employment, future communities, and future families and homes.

This is the desired ripple effect. With the context of ecological crises stemming from anthropogenic activity, this study aims to provide cost-effective, pragmatic and scalable interventions for reducing the use of water and electricity in university residences.

## **CHAPTER 2 - LITERATURE SURVEY**

### **2.1. Introduction**

This chapter briefly discusses the effects of human activity on the planet, on a global scale and then discussed in a South African context. The global shortage of water and the need for alternative and eco-friendly energy sources will be discussed. South African circumstances with regards to both water and electricity supply will also be discussed.

Thereafter, literature around the construct of attitude – its definition, complexity and measurement – will be discussed. The concept of behaviour will then be discussed, as will be its measurement. The relation between behaviour and attitude will be examined, with a particular focus on the Theories of Reasoned Action and Planned Behaviour.

Literature around behaviour change will be examined, as well as the efficacy of interventions. Universities and their efforts to reduce water and electricity consumption will be briefly discussed. The discussion will then focus on the impact of residence students' consumption patterns and interventions applicable to resident students.

### **2.2. Homo sapiens: development at all costs?**

Homo sapiens (human beings) have always sought to push back the frontiers of their development. They have learned to harness, manipulate and channel natural forces and resources to this end. Human ingenuity has made nuclear fission a source of substantial amounts of energy. The same process was also responsible for the Chernobyl disaster in the Ukrainian SSR in 1986.

Meadows, Meadows and Randers (1992) argue that powerful trends run against each other in the world. They state that in most parts of the world, capital growth exceeds population growth. However, in the remaining few, the reverse is true. They further suggest that people who are getting richer are demanding more industrial product, energy and cleaner air. This sits in contrast to poor people, who are struggling to get potable water, arable land and firewood as a fuel source. Lastly, they add that while some non-renewable and renewable resource stocks are being depleted, some are being used more efficiently. This argument is aimed at highlighting that human development has both beneficial and detrimental consequences.

The cost of this development is what is of importance. At what lengths, and at what costs are humans going to preserve and develop themselves as a species? Underpinning and enabling human activity, geared towards preservation and/or development, are natural systems. These systems need to be protected, as we have one planet. All of us have to share her resources, not only as Homo sapiens, but with other organisms as well. We therefore have a responsibility to other humans and to all organisms that our lifestyles and industrial activity do not adversely affect us existentially in the present and in the future. This is difficult because our industrial activity has been used to feed excessive consumption of goods and services, whose production means added strain on natural systems. As a species, we have embraced consumerism.

### **2.2.1. Consumerism**

Consumerism, as is more commonly used today, can be defined as the “emphasis on or preoccupation with the acquisition of consumer goods” (Oxford English Dictionary, n.d.). We are consumers in the sense that we utilize that which has been produced to meet basic needs, but we now consume in excess. Crocker (2013) posits that historically, access to goods was the main pursuit of the many who saw consumption as a route to a better standard of living, a progression of human development. Crocker (2013) further adds that access, when achieved, became a gateway to excess. This means that when people had more disposable income, when goods became cheaper due to the cost-effectiveness of mass production, and when goods were more readily available, excessive consumption became possible. Industrial mass production is the main driver of this excess, as it created the capacity for it to be achieved.

Crocker (2013) continues to highlight that beyond mass production, other drivers of consumption are at play. The marketing and media industries have mastered the art of persuading people of ‘needs’ they do not really have and how a certain product or service offered can meet that need. This has led to premature replacement of products, meaning that many products bought do not reach the end of their useful life (Lilley, Smalley, Bridgens, Wilson & Balasundaram, 2016:pp355-356). Continuous technological advances that make it possible for the regular replacement of goods facilitate this relentless pursuit of newer technology. Other strategies used include enticing consumers to purchase at a bargain products that they would not generally be able to afford, creating artificial obsolescence, providing credit facilities and downplaying what consumers have already as not as satisfying as what they could get. Finally, all this systemic integration of factors not only promoting but also exacerbating consumption has taken a long time to get running as a well-oiled machine. Therefore, addressing the reality, that consumerism is not an individual problem but a societal one, is seen as not worth it, due to the ‘sunk cost effect’. The sunk cost effect makes it difficult to withdraw from an unworkable

activity because too much has been invested already (Arkes & Blumer, 1985; Crocker, 2013; Gillan, Leland Jr, Davies & Walsh, 2004; Gowdy, 2008). It is for the same reason that nations tiptoe around large industries and corporations that blatantly destroy the environment.

With this context in mind, it is clear that trying to change individual behaviour is not enough, as the environment in which we live in is pro-consumerism. That is why progress occurs in pockets, where a few people are able to think past the cloak of deception weaved by marketers and corporations alike and really calculate the real costs of production and consumption (Collins-Chobanian, 2001). The reality is that the true cost is hidden while the pseudo-benefits are promoted. Even worse than that is the shifting of the cost to other players in the value chain such as producing parts in other countries or making artificial obsolescence a consumer problem (Jiang & Green, 2017).

The other problem is that nations recognize that production and consumption are politicized issues. Consumerism has also been justified by stating that increased consumption would result in economic growth and stability. As Orr (1994:70) suggests, the issue lies not with biological diversity or ecological degradation which are but consequences, but with the power struggles, wealth distribution and ownership of land. In essence, change in a country is not possible devoid of political concerns. For a country whose energy needs are met by coal-fired stations, trying to shift that country to renewable alternatives will meet head on with lobbyists, politicians and corporation-funded research all aimed at maintaining the status quo and moving on with business as usual. Governments, who have the power to use taxation, legislation, incentives, pricing and information as tools to manage demand for goods (Newton, 2013) find themselves doing the bare minimum, as environmental sustainability costs are harder to calculate as compared to social and economic sustainability ones. When working within a paradigm of 'production at all costs', it is easier to sacrifice the environment, especially when the system does not reward its conservation.

While the issue of consumerism is not an issue that can be tackled by focusing on individuals only, individuals make these choices. Consumerism at its core reflects the philosophical viewpoint of anthropocentrism. Anthropocentrism refers to humankind seeing themselves as superior to all other created things, thus justifying the degradation of the environment if it is in the interest of moving the species forward. It is this worldview that has facilitated industrialization, a worldview that promotes fragmentation and compartmentalization of what is naturally systemic, that separated mankind from the rest of mankind and continued on to separating humankind's mind from its body (Orr, 1994:31). It has Descartes and Galileo as its more prominent architects (Capra, 1996:5, 19).

As an anthropocentric behaviour, consumerism needs to be addressed from a worldview level. This is because our worldview is our perspective, the lens with which we view the world. Our perspective needs to be changed as it is outdated and cannot process the reality of a globally interconnected world (Capra, 1996:4, 6). We need this worldview change quickly because we are pushing natural systems too far.

### **2.2.2. Development on Earth: a system with limits and the need for adaptation**

Meadows *et al.* (1992:1) defines overshoot as the inadvertent crossing of boundaries. They further suggest that overshoot requires three conditions for it to occur. Firstly, there has to be rapid change or action. Secondly, there must be a limit or barrier in place, which the aforementioned change or action should not cross. Finally, there must be inability to control the change, caused by a delay in the feedback, faulty or insufficient data, inattention or the sheer momentum of the action or change. This idea can be applied to everyday examples of like overgrazing, overspending of money and overdosing on medication. However, this study will use this framework to discuss the overshoot that is occurring on a global basis.

Rockström *et al.* (2009a) suggest that there are nine planetary boundaries (critical thresholds) that should not be overshoot. Unfortunately, of the nine, they add that humanity has overshoot three already. These are the nitrogen cycle, biodiversity and climate regulation. They further posit that humanity is approaching the boundaries of freshwater use and land-system change.

The concept of overshooting forms part of a worldview that sees the Earth and its ecological functions as a system. A worldview is defined by Aerts, Apostel, De Moor, Hellemans, Maex, Van Belle and Van der Veken (2007:8) as "...a coherent collection of concepts and theorems that must allow us to construct a global image of the world and in this way to understand as many elements of our experience as possible." Hes and Du Plessis (2015:22-27) suggest that the world is actually a social-ecological system, and that while we ourselves are an ecosystem, we are part of the global ecosystem. The United Nations (1987:11) concurs, stating that the Earth can be considered as an organism, and that this organism's health is dependent on the health of all its parts. This is in line with the Gaia hypothesis, which suggests that the Earth can be considered as a self-regulating super organism (Bjornerud, 1997:89). This worldview that sees the world systemically can be called an ecological worldview, and it reflects an appreciation that even humans are but a strand in the web of life (Capra, 1996:35).

There is a need to change from the mechanistic and fragmented worldview that Descartes and Newton fostered, to a holistic and ecological one (Bjornerud, 1997:pp 91; Du Plessis,

2009:164). Holism, as a concept, augments the systems thinking approach by stating that the whole is more than the sum of its parts (Smuts, 1987). These two related concepts are fundamental to an ecological worldview. An ecological worldview allows us to make sense of how powerful trends can run against each other, and why a linear model of the world is impossible (Meadows *et al.*, 1992). It also makes us think deeper about our proposed solutions to problems in the world.

As aforementioned, Meadows *et al.* (1992:45-46) argue overshooting from a worldview that considers the planet as a system: one with a dynamic balance of its sources and sinks, which are both subject to limits. Sources and sinks connote materials and energy, and wastes and pollutants, respectively. Meadows *et al.* posit that on both the Earth's sources and sinks, there are limits imposed by the Earth's processes of regeneration, regulation and absorption. If the rate of consumption of natural resources by humans and their industrial processes exceeds the rate of Earth's regeneration of these resources, source limits will eventually be encountered (Meadows *et al.*, 1992:45). The same applies to the wastes and pollutants: humans and their activities should not exceed the rate at which the Earth is able to absorb them, as the sink limits will be encountered.

With cognizance of the limits in place, there needs to be a consideration of the delicate balance that is in place between the Earth and both the biotic and abiotic elements that are found on it. Huggett (1997:6) states the overarching term 'ecosphere' consists of subdivisions, namely the atmosphere, biosphere, hydrosphere, pedosphere and troposphere. Huggett further posits that changes to the environment emanate from three areas. Firstly, they are from the ecosphere itself. Secondly, changes come from the Cosmos or the cosmosphere. Thirdly, changes come from the solid Earth, which is composed of the lithosphere and barysphere. This argument suggests an interconnected universe, and that a system is affected by its environment. Goudie (1986:3) states that one of the basic laws of ecology is that everything is interconnected and that one cannot change one thing in nature without affecting the whole.

This idea is important when discussing climate change, as the vulnerability of populations to it can manifest in various ways. This is because the behaviour of humans in affecting one component of this ecological system can have fallouts in other components. Furthermore, the behaviour may be of others, but due to the interconnectedness of the planet, innocent parties may face the consequences. Climate change, which is a result of overshooting, leads to the vulnerability of people.

Barnett and Adger (2007:pp 641) state that the level of vulnerability of people to climate change is determined by 3 factors. First, how dependent are those people on natural resources and/or ecological services. Second, how susceptible are those resources and services to changes in the climate. Third, the people's ability to adapt to changes in these resources and services (level of adaptive capacity). In essence, communities dependent on natural capital are more vulnerable than those dependent on economic or social capital. Mukheibir (2010:pp 1030) suggests that poorer communities and countries are devastated by climate change not because of the direct impact, but because of the inability (lack of adaptive capacity) to respond to these impacts. This adaptive capacity is split into two forms.

Firstly, there is resilience-type adaptation, which in anticipation of extreme climate events, seeks to enhance resilience and lower sensitivity to the occurrence of these events. Secondly, acclimation-type resistance seeks to reduce sensitivity to the change in mean conditions. There is an expectation that trends will emerge or key thresholds in climatic drivers will exist. Both are necessary but are minimally prioritized in policies in developing countries, as developing adaptation capacity is capital intensive. Sectors like agriculture, which are historically geared to address climatic threats like drought, work to integrate adaptation. However, at national level, integrating adaptation capacity for climate change is seen as long-term and less pressing than issues like food security and HIV/AIDS programmes (Mukheibir, 2010:pp 1034).

Another observation is that the factors that cause or eradicate these vulnerabilities do not generally emanate from the communities themselves (Barnett & Adger, 2007:pp 641). This is why dealing with the issue of water security is more complex. When a country has issues around energy security, local interventions such as policy, taxation and government expenditure can alter the conditions. With climate, the effects are generally regional or even global. Therefore, when a single country attempts to rectify the situation it may not be as fruitful as anticipated. Thus, water security is a global issue, for whether a country is perpetrator or victim in terms of the adverse effects on water security, all are affected.

### **2.2.3. Development must meet needs**

The United Nations (1987:41) definition of sustainable development captures this idea: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The WCED definition highlights the concept of needs and the idea of limitations. While the idea of limits has been discussed, the concept of needs has not. Needs will be discussed from a sustainable

development point of view, and the focus will be on the Millennium Development Goals, and their successor, the Sustainable Development Goals.

The Millennium Declaration was adopted in September 2000 and Millennium Development Goals were established (Pronyk, Muniz, Nemser, Somers, McClellan, Palm, Huynh, Amor, Begashaw, McArthur, Niang, Sachs, Singh, Teklehaimanot & Sachs, 2012:pp 2179). The eight Millennium Development Goals are:

- 1) to eradicate extreme poverty and hunger;
- 2) to achieve universal primary education;
- 3) to promote gender equality and empower women;
- 4) to reduce child mortality;
- 5) to improve maternal health;
- 6) to combat HIV/AIDS, malaria, and other diseases;
- 7) to ensure environmental sustainability; and
- 8) to develop a global partnership for development (World Health Organization, 2017).

These have been superseded by the Sustainable Development Goals, which came into force in 2016. These form part of the 2030 Agenda for Sustainable Development, and are to be read with the complementing 169 targets. These were adopted at the UN Summit in September 2015, and while they are similar to the Millennium Development Goals, they are broader in scope. They are as follows:

- 1) end poverty in all its forms everywhere;
- 2) end hunger, achieve food security and improved nutrition and promote sustainable agriculture;
- 3) ensure healthy lives and promote well-being for all at all ages;
- 4) ensure inclusive and equitable quality education and promote lifelong learning opportunities for all;
- 5) achieve gender equality and empower all women and girls;
- 6) ensure availability and sustainable management of water and sanitation for all;
- 7) ensure access to affordable, reliable, sustainable and modern energy for all;
- 8) promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;
- 9) build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation;
- 10) reduce inequality within and among countries;

- 11) make cities and human settlements inclusive, safe, resilient and sustainable;
- 12) ensure sustainable consumption and production patterns;
- 13) take urgent action to combat climate change and its impacts;
- 14) conserve and sustainably use the oceans, seas and marine resources for sustainable development;
- 15) protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;
- 16) promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels;
- 17) strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

The United Nations (2016) highlights five differences between the Millennium Development Goals and the Sustainable Development Goals:

- 1) The Sustainable Development Goals cover the sustainable development from a tripartite approach: economic growth, social development and environmental protection. This makes them broader in scope as they intend to deliver development for all people.
- 2) The Sustainable Development Goals are more ambitious, and cover more in terms of the focus points in the sustainable development agenda.
- 3) The Sustainable Development Goals are universal, applying to all countries. This is different from the Millennium Development Goals, which targeted developing countries.
- 4) The Sustainable Development Goals are implementation orientated, mobilizing financial, data and technology resources, and building capacity where it is lacking.
- 5) The Sustainable Development Goals reflect understanding that addressing climate change is paramount in the effort to eradicate poverty and achieve sustainable development.

These goals reflect important human needs. They are also interdependent in that tackling one will inadvertently begin or require tackling another (World Health Organization, 2017). They reflect an understanding that development that meets human needs that should be balanced with the needs of all species inhabiting this planet. The global economies, being so industrialised, have one major need that must be met: the need for energy.

### **2.3. Global need for energy**

Solar energy is the primary source of energy in the ecosphere (Huggett, 1997:7), and drawing the matter closer to home, for biological processes in organisms. It is synthesized by plants,

that in turn are eaten by animals. In its natural state, the Earth is able to function without additional energy input other than that of the sun. However, human activity requires additional energy in various forms.

Fire was used for this purpose, with the fuel being predominantly wood. However, industrial advances have brought about other fuels such as oil and its products, natural gas and coal. These fossil fuels, however, require digging and/or drilling to access. The large quantities needed and the difficulty of extraction are the main reasons why acquisition of these fossil fuels is environmentally damaging (Sale, 2011:239). Nevertheless, even more damaging are the greenhouse gases released from burning them. Fire has the drawback of being hard to manipulate or use as one pleases. Humankind's industrial pursuits took productivity beyond the limits of fire to a better and more versatile energy source: electricity.

### **2.3.1. From fire to electricity**

Electricity powers the majority of modern day human activities. Even for those historically known to be fire dependent, advances in technology has allowed for the switch to electricity for basic applications such as heating (and cooling), lighting and cooking. On the domestic front, fire has become something reserved for very limited applications in developed countries. It must be noted, however, that in traditional cultures even within developed countries, fire remains the primary source of energy (Zerboni, Mori, Bosi, Buldrini, Bernasconi, Gatto & Mercuri, 2017).

Industrial processes consume a lot of electricity, as it is used for the processes themselves, processes that provide, among other things, the residential sector with goods for human comfort and support services. Technology continues advancing and the number of applications of electricity on the domestic front have consequently increased as well. Hygiene, security, house chores, communication, entertainment, work and academic activities all use electricity nowadays.



**Figure 1: Earth at night**

**Source:** [https://eoimages.gsfc.nasa.gov/images/imagerecords/55000/55167/earth\\_lights\\_lrg.jpg](https://eoimages.gsfc.nasa.gov/images/imagerecords/55000/55167/earth_lights_lrg.jpg)

Satellite images of Earth show that there is an increase in uptake of electricity used in the developing world. There is a growing demand for electricity that has spurred projects of building new hydroelectric plants, building new and upgrading coal-fired power stations, and investigations into stations powered by nuclear energy and by renewable energy sources. This great demand has produced rolling blackouts in some countries and has made electricity supply non-reliable. This has also produced support for the sustainability agenda, as these occurrences have provided evidence of a need to change current consumption patterns of electricity. Consumers have been educated on energy-saving techniques, and in some instances, incentives given for environmentally sustainable behaviour. All this highlights that electricity is not a naturally occurring resource: it needs to be produced.

### **2.3.2. Producing electricity**

Globally coal remains the leading fuel used in electricity generation, with a 2.5% increase from 1973 to 2014 (International Energy Agency, 2016b:24). 40% of global electricity generation utilizes coal as a fuel (International Energy Agency, 2016a:43). The People's Republic of China is the leading producer of electricity using coal, accounting for 17.3% of production globally. Other major producers are the United States of America, India, Japan, Germany, South Africa, Korea, the Russian Federation, Australia and Poland, respectively (International Energy Agency, 2016b:25). Saudi Arabia is the global leader in generating electricity from oil, accounting for 14.9% of global generation. The United States of America leads in generating

electricity from natural gas, being responsible for 22.5% of global generation (International Energy Agency, 2016b:25).

Coal is a rock and needs to be dug out. This process causes a great deal of waste material in the form of rock and other ground material. The aggravating factor is that, unlike oil that is found in wells, coal must be dug out from where it is and that causes coal operations to be large in scale (Goudie, 1986:197; Sale, 2011:244). These operations also create and/or modify landforms, and further alter the operation of geomorphological processes. Other human activities affecting geomorphological processes (anthropogenic processes) are constructional, other excavation activity and hydrological interference (Goudie, 1986:191-192). The effects of anthropogenic processes that this study will consider are those to landform and the water system. These can be regarded as effects to the pedosphere and hydrosphere, respectively.

The extraction of oil used to be limited to onshore explorations and offshore drilling focused on oil wells. With the increase in demand for, there is extraction of product from sources such as oil shale and tar sands. These deposits are immense, long-ignored and low-grade (Sale, 2011:241). If one considers Canadian operations, one can appreciate the effects on the environment. Operations extracting oil from Athabasca deposits produce approximately 2 metric tons of waste for every barrel of oil. Goudie (1986:197) estimates a 1: 3 ratio of oil to excavation required, on a volume basis. The energy requirement for the process is also great. It is estimated that it takes energy equivalent to 2 barrels of oil to extract 3 barrels of oil from the Athabasca deposits (Sale, 2011:242-243).

The Organization of Oil Producing Countries (OPEC) has in its membership the leading oil producers and exporters globally. It states that all its members are signatories to the United Nations Framework Convention on Climate Change (UNFCCC) and have the protection of the environment as a priority (Organization of Oil Producing Countries, 2017). OPEC states that with the long-term outlook, fossil fuel will still provide the bulk of our energy needs. HE Dr. Mohammed Bin Saleh Al-Sada, Qatar's Minister of Energy and Industry and President of the OPEC Conference at the OPEC Consultative Ministerial Meeting in September 2016, stated that demand for oil in 2016 was expected to grow by 1.2 million barrels a day, and similar growth was anticipated in 2017.

### **2.3.3. The real cost of energy**

This model of electricity production, one powered by fossil fuels, is the cause of great amounts of pollution, which cause other harmful effects like respiratory diseases. The International Energy Agency states that 85% of all particulate matter and almost all SO<sub>x</sub> and NO<sub>x</sub> emissions

are the result of the production and use of energy. It adds that this is due to unregulated, poorly regulated or inefficient combustion (International Energy Agency, 2016a:13). Not all fuels emit all the pollutants and the various grades of the fuels contain varying amounts of the pollutants. However, certain pollutants can be associated with these fuels. For example, coal accounts for more than half of all energy-related SO<sub>2</sub> emissions, followed at a distance by oil. Oil is responsible for most of the NO emissions, followed by coal. Natural gas has lower emissions as, in the effort to combat pipeline erosion, sulphur is removed as soon as possible after production (International Energy Agency, 2016a:38-39). All these emissions, in their various types and concentrations, feed into the global crisis of climate change, which is why we need to limit the use of fossil fuels.

The cost of energy can no longer be limited to the monetary expenditure utilized in the acquisition, production and distribution of fuels. It must include non-monetary costs, for externalities such as poor health, loss of biodiversity and expedited climate change, and the Brent price of oil cannot fully reflect that.

#### **2.3.4. Conclusion**

Energy is an existential need. Throughout the ages, humankind has harnessed and manipulated sources of energy of various kinds to preserve and develop itself. Our current industrial processes, especially in electricity generation, utilize substantial amounts of fossil fuels. This in turn causes substantial greenhouse gas emissions. Since our journey to renewables has hurdles in the short-term, we need to reduce our consumption of electricity, as the energy sources for its generation will remain the same in the near future.

#### **2.4. Energy demand of South Africa**

South Africa imports 95% of its crude oil requirements, as it has small deposits of conventional oil. This makes crude oil the single largest commodity South Africa imports, which is imported from West Africa and the Middle East. Its synthetic fuels industry, which produces petrol and diesel from coal and natural gas, is highly developed. This fuel is used primarily in the transportation sector (Department of Energy, 2014:2).

Sasol Gas Ltd is the only supplier of natural gas in South Africa. PetroSA also produces natural gas, but for its sole use. Sasol Gas Ltd imports natural gas from Mozambique and then produces synthetic gas (methane rich) in its Secunda plant. This gas is sold to other companies within the Sasol Limited Group, to gas traders and industrial customers (Department of Energy, 2014:46). The large amounts of coal are used primarily in the electricity sector, with about 28%

exported through the Richards Bay Coal Terminal. South Africa's geographical position enables viable trade with both the Atlantic and Pacific basins (Department of Energy, 2014:52).

The National Energy Regulator of South Africa (NERSA) has a mandate of regulating the South African energy industry, including regulating electricity tariffs and prices (Department of Energy, 2014:55).

#### **2.4.1. South Africa's demand and supply of electricity**

South Africa gets most of its electricity from a parastatal called Eskom (Thopil & Pouris, 2010:4). Eskom has its national control centre at Simmerpan, Germiston, and this controls the power transmission throughout the country. Eskom is also major player in the Southern African Power Pool. As coal is the most abundant fossil fuel in South Africa, Eskom uses it in power generation, with stations built adjacent to mines. Approximately 90% of the power Eskom produces is from coal-fired power stations, using over 90 million tons of coal per year for its operations (Eskom Holdings S.O.C. Ltd, 2015b; Thopil & Pouris, 2010:4; Winkler, 2007:pp 27). This is approximately 53% of South Africa's coal production. Eskom estimates that the country's coal reserves are estimated at 53 billion tons, and at present production rates, should last for about 200 years (Eskom Holdings S.O.C. Ltd, 2006). Thopil and Pouris (2010:4) state that this estimate has been disputed by the Department of Minerals and Energy, which has set a temporary estimate of 38 billion tons. They add that with growth rates at 3 – 5%, this reserve would be depleted in 40 – 50 years, necessitating focus on diversifying the methods of electricity generation.

The argument for diversification is also supported by the immense greenhouse gas emissions that come from using coal as a primary source of energy (Winkler, 2007:pp 28-29). South Africa's CO<sub>2</sub> emissions were reported to be 437.37 Mt in 2014, 39.6% of Africa's 1 105 Mt (International Energy Agency, 2016b). It has been recognized as one of the highest emitters of CO<sub>2</sub> per capita in the world (Department of Minerals and Energy, 2005:10; Sebitosi, 2008:pp 1591). Other pollutants include SO<sub>2</sub>, NO and particulate matter. In their study on electricity externality analysis in South Africa, Thopil and Pouris (2010:1) highlight that the monetary consideration of these externalities increases the cost of producing electricity, a practice more prevalent in developed countries and lacking in developing ones. In South Africa, if Eskom accounted for externalities, maybe electricity costs would not be as low, according to world standards.

The need for diversification can be seen by considering Eskom's plant mix. Currently Eskom's plant mix consists of:

- 16 coal-fired power stations (Medupi and Kusile are under construction and/or not fully synchronized with the grid)
- 1 nuclear power station
- 2 hydroelectric power stations
- 3 hydro pumped storage schemes (Ingula, a scheme in Ladysmith, KZN, came online recently)
- 4 quick reaction gas turbines
- 1 wind farm

The coal-fired power stations carry the base load and operate for 24 hours a day. The same applies to the nuclear station at Koeberg. The hydroelectric stations and the hydro pumped storage schemes are used when there are sudden peaks in demand, which the base stations cannot meet quickly. The four quick reaction gas turbines are used in peak periods and in severe emergencies, as they have high operating costs: two run on kerosene and two run on diesel. The use of the wind farm was not stated in the literature (Eskom Holdings S.O.C. Ltd, 2016a). It is clear that a greater use of alternative energy sources has to be invested in, possibly allowing base loads to be carried by stations using clean/cleaner energy sources. Eskom intends to reduce coal use to 70% by 2025, increase nuclear power from 17% to 28% in 2025, and use solar energy and wind power to produce 1 600 MW in 2025 (Eskom Holdings S.O.C. Ltd, 2007:v).

Fossil fuels are not the only natural resources used by Eskom in power generation. In 2007, Eskom's water consumption rose by 21 548 Ml year-on-year from 2006. One of the reasons is the running of coal-fired stations for longer, sometimes at lower efficiency (Eskom Holdings S.O.C. Ltd, 2007:viii). Water, apart from being used to produce the steam required in electricity generation, is also used in wet cooling at the stations. Eskom reported consuming 1.9% of South Africa's freshwater. It further warned that power stations in the Mpumalanga Highveld may not have sufficient water due to increase in demand and due to drought (Eskom Holdings S.O.C. Ltd, 2007:41). Water became an issue requiring greater consideration then, at the beginning of Eskom's supply woes. In 2015, water supply became an issue for coal-fired stations in the Vaal River system and the hydro stations in the Orange River system. Emergency generation of the hydro stations ceased in October 2015. The El Nino weather pattern caused low rainfall and dam levels fell, prompting Eskom to develop contingency water supply plans (Eskom Holdings S.O.C. Ltd, 2016b:46). Water supply and electricity generation are unfortunately inextricably linked for South Africa, with the current plant mix.

In 2008, South Africa experienced an energy crisis that made blackouts or load-shedding common in the country, beginning in the first quarter. Load-shedding is used to protect the system from a nation-wide blackout (Eskom Holdings S.O.C. Ltd, 2015a:22). Inglesi and Pouris (2010:2) suggest that the crisis was caused by an imbalance in supply and demand. They add that this is due to the government delaying funding for the building of a new power station while there was a 50% increase of electricity demand between 1994 and 2007 in the country. This increase in demand, they suggest, is due to the economy's expansion when sanctions were lifted and also the 2001 Free Basic Electricity Policy. This is because the post-1994 South African government has shifted focus to increasing household access to electricity and making electricity more affordable for the poor (Winkler, 2007:pp 26). The case for economic expansion is supported by the Department of Energy (2015:25), which states that rapid post-1994 economic growth flouted decades of planning in the sector. Further support is provided by Becker and Fischer (2013:pp 446), who state that for emerging economies, there is a strong correlation between economic growth and the demand for electricity. They also concur that access to affordable electricity is not only about economic growth, but also about social development, and there is immense pressure to achieve universal access in South Africa and India (2013:pp 453).

In 2003, a decision was taken that 3 power stations that had been mothballed, namely Camden, Grootvlei and Komati be brought back online (Department of Energy, 2015:25; Department of Energy, n.d.). In 2005 already, the Department of Minerals and Energy predicted a need for investing in additional power generation capacity in 2007 when considering power usage levels then and projected economic growth (2005:23). The 2008 shortfall in generating capacity was about 10%, reflected as a low reserve margin (Becker & Fischer, 2013:pp 451; Sebitosi & Pillay, 2008:pp 3312). The increase in demand caused power stations to run at full capacity, and impeded the necessary planned maintenance downtime as only a few stations could be offline (Becker & Fischer, 2013:pp 451). This causes more breakdowns. The philosophy of keeping lights on at all costs being of greater importance than the maintenance philosophy has indeed placed Eskom in a tough situation (Eskom Holdings S.O.C. Ltd, 2015a:4).

Eskom still needed to increase production capacity, and two coal-fired power stations, Kusile and Medupi projects were initiated (Blignaut, Inglezi-Lotz & Weiderman, 2015:1). These are to be operational in 2018. Another project was hydro pumped storage scheme, Ingula (Department of Energy, n.d.-b, p. 25), which has come online. Project Sere, a wind farm in the Western Cape, came online in 2015 and has a production capacity of 100 MW (Eskom, 2015, p. 19).

NERSA appreciates the role of the private sector in electricity generation, and seeks to fast track the licensing of Independent Power Producers (IPPs). IPPs are poised to introduce technologies that are not on the fore of Eskom's operations. During the 2015/16 period, NERSA granted 26 IPPs with licences. IPPs are part of Renewable Energy Independent Power Producer (REIPP) (National Energy Regulator of South Africa, 2016, p. 15).

The cheap cost of coal mining and its abundance has made South African electricity tariffs cheaper when compared to rest of the world (Becker & Fischer, 2013, p. 6; Blignaut et al., 2015, p. 1; Thopil & Pouris, 2010, p. 4; Winkler, 2007, p. 1). Eskom procures coal at a cost-plus that is significantly lower than the international price at Richards Bay (Department of Energy, 2016, p. 52). This has led to its inefficient use, which is problematic for a country that has an energy-intensive economy. This sentiment is echoed clearly in opening lines of the Department of Minerals and Energy's Energy Efficiency Strategy (2005, p. i) in saying, "In South Africa we take energy for granted, with the consequence that our energy consumption is higher than it should be. Indeed, our country's economy is largely based on minerals extraction and processing which is by its nature very energy intensive. Whilst our historically low electricity price has contributed towards a competitive position, it has also meant that there has been little incentive to save electricity."

Eskom and NERSA have increased electricity tariffs through a revision of the tariff structure (Blignaut et al., 2015, p. 1). These increases have been across all sectors, and in real terms, Eskom's prices have tripled. This has been due to the regular use of diesel-fired plants used to meet peak demands (Department of Energy, 2016, p. 55). In 2013, NERSA approved the 8% per annum aggregate price increase for the next 5 years (MYPD3), and then in 2014, NERSA approved Eskom's application to increase the price by 12.69% for the 2015/16 financial period (Department of Energy, 2016, p. 59).

The issue of security around the supply of electricity is not one Eskom can solve alone. NERSA acknowledges that demand for energy is on the rise globally (National Energy Regulator of South Africa, 2016, p. 17), with the IEA estimating a 37% increase by 2040 (International Energy Agency, 2014, p. 1). When load-shedding was first instituted, the Minister of Minerals and Energy as well as Eskom, appealed to consumers to cut down on their consumption (A. B. Å. Sebitosi, 2008, p. 1). The Department of Minerals and Energy recognized that making the public aware of the costs and benefits of energy efficiency was a neglected point of intervention. It also recognized that significant energy saving can only be achieved by changing

people's behaviour (2005, p. i). A. B. Á. Sebitosi (2008, p. 2) states that it commonly accepted that the most efficient energy conservation model is a four-tier model of prioritization:

- At the top, it focuses on changing human behaviour to reduce demand;
- Second, it is the utilization of energy-efficient appliances/tools/machinery that represent improved technology;
- Third, it is power generation from renewable and sustainable resources;
- Moreover, the bottom, as a last resort, it is power generation by the exploitation of conventional energy resources.

This model emphasizes the change of human behaviour over design. Tetlow, Beaman, Elmualim and Couling (2014:pp 234-235) state that the behaviour of people in buildings designed to be energy efficient, thermally efficient and designed with integral zero/low carbon technologies is commonly considered to be the cause of the 'performance gap'. They further add the construction industry has responded with removing of the environment from occupants by implementing automation technologies. These technologies, if not installed, calibrated and maintained correctly inadvertently become a cause of dissatisfaction and discomfort.

#### **2.4.2. Domestic energy use in South Africa and the need for behaviour change**

On the domestic front, South Africans use energy primarily for lighting, cooking and heating. Concerning lighting, electrified homes reported in 2012 to using electricity almost exclusively, with a marginal group reporting continued reliance on candles. With non-electrified households, the majority (59%) rely on candles, while 36% rely on paraffin; the rest of the sources are nominal, with each not amounting to more than 2% (Human Sciences Research Council, 2013, p. 2).

77% of households in South Africa primarily use electricity for cooking, whilst 10% report using firewood as their main energy source. For non-electrified households, 54% used firewood predominately and 38% used paraffin predominately for cooking purposes. The use of paraffin decreased by 12% in 2012 from 2011, while use the use of firewood increased by 14% in the same period. This increase in firewood use is suggested to be a product of higher paraffin prices, as firewood is paraffin's substitute good (Human Sciences Research Council, 2013, p. 2). Concerning domestic space heating, in 2012, 45% of electrified households reported using electricity predominately. 39% reported not using energy at all, but instead wear warm clothes, use blankets or use nothing at all. Of the remaining 7% use firewood, 4% use paraffin and 5% use other sources.

Eskom has used several ad hoc interventions aimed at changing human behaviour. This includes Power Alert on SABC and DStv channels, system power bulleting biweekly, and even use of social media to keep the public updated about load-shedding (Eskom, 2015, p. 23). Eskom has also embarked on the Demand Side Management, with one method being hiking electricity tariffs by 140%, as was seen during the 2008/09 and 2012/13 years (Bohlmann, Bohlmann, Inglesi-Lotz & van Heerden, 2016:pp 451). Other methods that Eskom employed include providing subsidies for those installing compact fluorescent light bulbs and/or solar water heaters. This reflects an understanding that millions of South Africans making small changes can affect the electricity demand greatly.

### **2.4.3. Conclusion**

South Africa is a country that is entrenched in fossil fuel use for energy production. This creates large amounts of greenhouse gases, adding to our problems around global warming. While the construction industry looks to automation and green design as a way to counter the inefficient use of electricity in houses, at the core of the matter is human behaviour. On the domestic front, the power of community can be leveraged to make small efforts have a great impact in reducing the demand for electricity. Eskom has also tried implementing interventions aimed at the domestic consumer to try to reduce national consumption of electricity.

## **2.5. The global need for water**

Water is second only to oxygen in terms of being a necessity to sustain life. Water is an existential need for both humankind and other organisms. The adult human body's weight is 45% - 70% water. We need water to have and maintain proper physiological function (Subudhi, Askew & Luetkemeier, 2005:pp 581). Water security is an important current issue, and is flagged in several studies as a possible cause of violent conflict in the future (Barnett, 2003; Barnett & Adger, 2007; Nordås & Gleditsch, 2015; Reuveny, 2007). Water use has been increasing at a higher rate than population growth. Between 1995 and 2008, global water use grew by 37.3% (Arto, Andreoni & Rueda-Cantuche, 2016). Water is used extensively in production, from electronics to energy to clothing. Its role in the value chain has been heightened by our consumerism. We utilize a lot of water for various needs and functions.

### **2.5.1. Food security and the looming three-pronged crisis**

The IPCC (2007:787) lists food supply as a key vulnerability based on the distribution and magnitude of its impact, and links this to the rising temperature. Our other great concern though is that our food security is largely dependent on the availability of water. Both rain fed and irrigated agriculture require water. 80% of the world's agricultural land is rain fed and contributed to 60% of global food output. 19% of agricultural land is irrigated and contributes

to the remaining 40% of global food. Irrigated agriculture accounts for approximately 80% of global water use (Belinskij & Kotzé, 2016:pp 366-367). Quantities of water utilised in irrigated agriculture are projected to increase by 50% by 2030 to guarantee food security (Rockström, Steffan, Noone, Persson, Chapin, Lambin, Lenton, Scheffer, Folke, Schellnhuber, Nykvist, de Wit, Hughes, van der Leeuw, Rodhe, Sörlin, Snyder, Costanza, Svedin, Falkenmark, Kalberg, Corell, Fabry, Hansen, Walker, Liverman, Richardson, Crutzen & Foley, 2009b).

Marine ecosystems are important to the food security discussion as they are a direct source of food and provide many with the means to purchase food. Globally, fisheries produce approximately 80 million tons of fish and fish-derived foods. Overfishing, pollution and climate change threaten not only the various species of marine life and their reproductive cycles, but threaten complete marine ecosystems (Ding et al, 2017). The deterioration in water quality and aquatic habitats has far-reaching and less understood consequences, as our marine ecosystems are a vital and integral part of an interconnected global ecosystem. We need to understand that everything that exist is fundamentally a part of an indivisible whole (Hes & Du Plessis, 2015:27).

Orr (1994:3) states that the tripartite crisis – food, end of cheap energy and exceeding ecological thresholds and limits of natural systems – feeds on itself, in that each part is the cause and outcome of another. Water is at the centre of it all. Its impact on food has been hinted on above. When it comes to cheap energy, countries that use thermoelectric power generation are vulnerable to water scarcity. Water deficiency results in reduction of electricity production, which translates into economic consequences in the form of electricity tariff hikes. Zheng, Wang, Cai, Kummu and Varis (2016) state that North China has several areas of vulnerability due to its water and electricity production conflicts. And finally, we are indeed pushing the natural limits of our water resources, exerting immense pressure on their ecological sink/source functions.

### **2.5.2. Potable water scarcity, access to water and climate change**

Potable water is a relatively scarce natural resource. This fact is counterintuitive as 71% of the Earth's surface is water. However, approximately 97.4% of the Earth's water is saline and is located in oceans, seas and bays. Of the total freshwater, approximately 77.23% is in icebergs, ice caps and glaciers. Freshwater lakes and rivers account for 0.35% and 0.003% of total freshwater, respectively. Cumulatively, groundwater accounts for 22.21% of freshwater, while the atmosphere accounts for 0.04% of it (Huggett, 1997:138; Jury & Vaux, 2007:6).

When hydrologists assess water scarcity, they do so by considering the population-water equation. According to the Falkenmark Water Stress Index, if a country has less than 1000m<sup>3</sup> per capita per annum, it is considered water scarce. Where the country has less than 500m<sup>3</sup> per capita per annum, it is considered to have absolute scarcity (Fischer, Zakar & Zakar, 2012:pp 294; Mukheibir, 2010:pp 1029). Mukheibir further adds that a shortcoming of the index is that it does not account for seasonality, local scarcity and/or political and social influences on allocation. Other indices used to assess water scarcity include the IWMI indicator, the criticality ratio and the water poverty index (Liu, Liu & Yang, 2016:pp 434).

Water scarcity is sometimes confused with lack of access to water. Access to water was declared a human right by the United Nations (Belinskij & Kotzé, 2016:pp 30). Mukheibir (2010:pp 1028) states that the right to water bears on the privatization discourse, as privatization of water services has at times infringed on the right, due to the inherent profit motive. He adds that tariffs and water markets reduce access, especially to marginalized communities. This is exacerbated by public utility providers who are slow in extending access, are corrupt and/or are inefficient (2010:pp 1029). Furthermore, water scarcity is used in the argument for why equitable global and local access to water is not possible. The two issues are similar in their consequences, and it is easy to mistake lack of access for water scarcity. The nexus between the two lies in that water scarcity, exacerbated by climate change will cause greater marginalization of the poor when it comes to water access (poor in this context connotes communities and countries) (Mukheibir, 2010:pp 1036). Mukheibir (2010:pp 1029) suggests that global water scarcity is not a matter of physical availability, but rather a product of power and inequality.

Barnett and Adger (2007:pp 641) state that climate change can be experienced in several ways, especially when considering its effects on water availability. Firstly, they state that mean conditions like temperature, annual precipitation levels and the sea level change, but these are long-term occurrences. Secondly, there is an increase in intensity and/or frequency of phenomena such as droughts, floods, cyclones, storms and epidemics. These effects can be experienced in the short-term. Thirdly, there are events of lesser certainty than the aforementioned two, but which still carry a high impact. These include melting of glaciers and permafrost, and drastic changes to the Asian monsoon and the El Niño Southern Oscillation phenomenon. El Niño events and the counterpart La Niña events have been the cause of devastating droughts and floods, depending on the region. Most of the aforementioned effects have a direct impact to water availability, distribution and quality. Fischer *et al.* (2012:pp 294) concur, stating that changes in freshwater consumption patterns and in the availability thereof is the most visible effect of climate change. The IPCC (2007:787) concurs with Barnett and

Adger (2007), and further warns that increases in temperature will cause increased salinization of coastal groundwater, further reducing water supplies.

Mukheibir (2010:pp 1029) states that it is more economical to invest in recycling, conservation and efficiency than developing new sources of water. Countries and institutions need to increase their resilience to deal with projected water-related constraints because water is a limited natural resource.

### **2.5.3. Human health and water pollution**

As water resources are relatively fixed, when populations grow, there is less water per capita. In water scarce environments, this can lead to the onset of dehydration. Dehydration has been linked to diminished cognitive capacity. This affects many children from poor communities and works adversely to keep them in the cycle of poverty (Santiago Ortiz-Correa, Resende Filho & Dinar, 2016). DeNicola, Aburizaiza, Siddique, Khwaja and Carpenter (2015:pp 344) argue that the discussion around water scarcity should not be limited to considering quantity but quality as well. Instances of waterborne or water-associated diseases such as cholera, malaria and bilharzia are exacerbated by water scarcity, as people and animals end up sharing and contaminating water sources (Wu, Lu, Zhou, Chen & Xu, 2016:pp 17). Wu *et al.* (2016:pp 19) state that diarrhoea morbidity increases as water becomes scarcer. The World Health Organization (2016) estimates there to be 502 000 diarrheal deaths per annum, and 1.8 billion people globally whose drinking water source is contaminated by faeces. In addition, water scarcity or the lack of safe drinking water plays a large role in causing malnutrition. Malnutrition weakens immune systems, making people more susceptible to disease (World Health Organization, 2001; Wu *et al.*, 2016:pp 18).

DeNicola *et al.* (2015:pp 345) suggest that climate change and the subsequent increase in temperature creates conducive conditions for certain waterborne pathogens to flourish. Extreme precipitation and subsequent flooding allows for disease outbreaks in non-traditional areas and times, increases the natural transmission period of pathogens and also washes other contaminants into potable water sources (Hofstra, 2011).

This dire situation, more prevalent in developing world, is further worsened by water pollution. Our agricultural activities have runoffs of pesticides, fertilizers and sediments that are deposited in many watercourses. Furthermore, urban/industrial waste of toxic metals, microplastics and petrochemicals also find their way into our water resources (Polidoro *et al.* 2017). Polidoro *et al.* (2017) found that banned (in the US) pesticides, heavy metals, plastics and their associated products were at toxic levels in several coastal streams. El Zeiny & El

Kafrawy (2017) assessed pollution at the Bullurus Lake (Egypt Nile Delta) and found that a lot of polluted water from domestic and agricultural sources was being discharged into it. Tsang et al. (2017) investigated microplastic pollution in marine water and sediments of Hong Kong and posit that sources of this pollution could be sewerage discharge, illegal dumping and industrial activities, among others.

#### **2.5.4. Conclusion**

It is evident that globally, water is a scarce resource that is used to meet conflicting interests. We need water for physiological reasons, to grow food, to cool our power plants and to produce the products that enhance our comfort and satisfy our needs. However, we are also the culprits of mismanaging our water resources. We pollute our water sources and affect the marine ecosystems, bringing about a loss of biodiversity. Water that is central to our health becomes a medium of carrying pathogens into our lives. Our ill health stunts our growth, raises the morbidity rate, affects our education and maintains the vicious cycle of poverty and social injustices. Water is central to our lives but we are failing to protect this scarce life-giving resource.

#### **2.6. Water demand of South Africa**

South Africa is rated among the 30 driest countries in the world (Alex & Pouris, 2016:pp 1106). Readings from 2000 indicate that that South Africa receives on average 450mm of rainfall per year, well below the global average of 860mm (Alex & Pouris, 2016:pp 1106; Department of Water Affairs, 2004:3). Water use sectors in South Africa are as follows: agriculture, urban use, rural use, mining and bulk industrial, power generation and afforestation. Of this demand, agriculture utilizes approximately 60%, urban use utilizes 15% and the rest is shared by the other sectors (Department of Water Affairs, 2004:8). There is consensus on the need to evaluate the agricultural sector's use of water, as it provides for 4.5% of GDP and 11% of total national employment (Department of Water Affairs, 2004:11). Since the water is used for irrigated agriculture, the water demand is directly linked to food supply/security.

The historic approach to water management in South Africa is a demand-driven one. However, the National Water Act (Act 36 of 1998) focuses on other issues such as universal access to water, maintaining the natural environment, and the sustainable and efficient use of water. While the demand for water can currently be met, it is projected that demand will exceed the supply of economically viable potable water by 2015 (DWAF, 2004, pp. 3–4). This projection does not account the effects of climate change. South Africa has 12 water boards, all established according to the Water Services Act (Act No. 108 of 1997). Their primary objective

is to “provide water services to other water services institutions within its service area” (Republic of South Africa, 1997, p. 30).

There are three major challenges to water distribution in South Africa:

- Uneven spatial distribution and seasonality of rainfall.
- Relatively low stream flow under normal circumstances, which makes them unreliable as sources.
- Location of large industrial, urban and residential developments far relative to larger watercourses, which necessitates immense transfer infrastructure (DWA, 2004, p. 3).

There is clear evidence that we are facing many challenges on the environmental front, both locally and globally. While some are a result of naturally occurring conditions, like countries being water scarce, some of these challenges are the result of human behaviour. In addition, in some instances, human behaviour exacerbates a naturally occurring condition. We may not be able to do much to better natural systems, but we can find ways to ensure that we curb ecologically unsustainable behaviour.

Current human behaviour patterns need to be changed, to be more ecologically sustainable. However, the overt actions done and words spoken by people are not spontaneous. They are the product of many factors. To understand why we behave the way we do, and how we can change it, we need to rely on models, theories and concepts from the field of psychology. This study will discuss these models, theories and concepts in an effort to see how interventions for behaviour change can be designed and implemented. While the study seeks to provide a complete understanding of human behaviour dynamics, it will not be exhaustive in terms of discussing the full ambit of social psychology.

## **2.7. Defining and understanding attitude**

Definitions are important as they provide boundaries between phenomena, underpin valid measurement, and provide a framework that facilitates theory development and empirical research (Eagly & Chaiken, 2007:pp 583). Attitude, a construct considered important and central to social psychology (Gawronski 2007, p.573; Schwarz & Bohner 2001, p.2), has been defined in various ways (Maio & Haddock, 2010:4). A few of these definitions will be discussed, as they will provide insight into the framework to be used in this study.

Eagly and Chaiken (1993:1) defined it as “a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour”. Allport (1935) defined attitude as “a mental and neural state of readiness, organised through experience, exerting a

directive or dynamic influence upon the individual's response to all objects and situations with which it is related." Ajzen and Fishbein (1980:17) suggest that although Allport's definition referred primarily to the evaluative function of attitudes, he nevertheless made it clear that the evaluative dimension was insufficient to encapsulate the complexity of the attitude construct. Furthermore, they state that Allport's arguments regarding the complex nature of attitudes were possibly the beginning of the development of the Multicomponent Model of attitudes.

Maio and Haddock (2010:4) have defined it as "an overall evaluation of an object that is based on cognitive, affective and behavioural information". This reflects their conceptualisation of attitude being in line with the Multicomponent Model of attitudes (Maio & Haddock, 2010:25). Furthermore, attitudes have valence and strength. Valence refers to direction, whether that evaluative judgement is positive, neutral or negative. Strength refers to degree of conviction the attitudes are held. Therefore, attitudes towards an attitude object can be held in varying strengths by different individuals (Maio & Haddock, 2010:4). The valence and strength of attitudes is important in understanding how attitude influence information processing and behaviour.

To further understand what an attitude is, Maio and Haddock (2010:25) posit that every attitude comprises of three overlapping components: content, structure and function (Ajzen, 1988:20). Attitude content refers to their conceptualisation of attitude comprising of cognitive, affective and behavioural components. These components are also referred to as cognition, affect and connotation, respectively (Ajzen, 1988:20). This will therefore be a discussion of the Multicomponent Model of attitudes. The cognitive component refers to the "beliefs, thoughts and attributes we associate with an object" (Maio & Haddock, 2010:25). This component, as the name suggests, has more to do with consideration of the attributes associated with an attitude object. For example, the attitudes of a buyer towards different products are formed through considering data sheets.

The affective component refers to "feelings and emotions linked to an attitude object", and in general it is the emotions which are aroused in response to an object that determines the influence of this component (Maio & Haddock, 2010:25). For example, seeing babies might arouse happiness, which in turn informs a positive attitude towards babies. Snakes, on the other hand, might arouse fear, thus informing a negative attitude towards them.

The behavioural component refers to "past behaviours or experiences regarding an attitude object (Maio & Haddock, 2010:25). For example, people who had painful injections as children may hold negative attitudes towards hospitals. Maio and Haddock (2010:26) refer to the Daryl Bem's Self-Perception Theory (referred to as SPT henceforth), which posits that when we

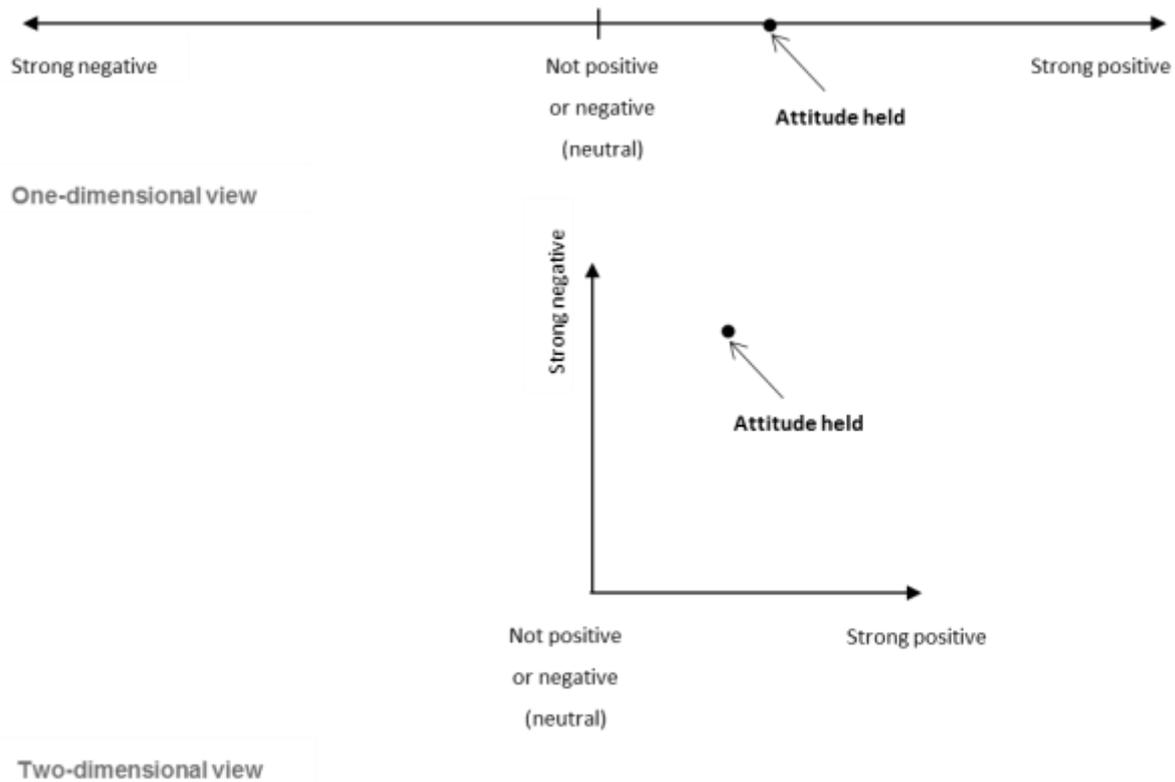
cannot access our opinions regarding an object, we can make an inference based on past behaviour and experience; this study will not discuss the SPT further.

Attitude structure refers to how the evaluative judgements are organised within the attitude content (cognitive, affective and behavioural component). This has two views, namely one-dimensional and two-dimensional (Maio & Haddock, 2010:34). The one-dimensional view assumes that an individual cannot hold conflicting attitudes towards the same attitude object, as negative and positive evaluations are on opposite ends of a single dimension. This is where valence and strength is relevant, as attitudes are perceived as points along a continuum.

It is the one-dimensional view that underpins Thurstone's measurement technique, as he believed that attitude measurement occurred on a continuum ranging from positive to negative. Thurstone's challenge was therefore developing a technique or techniques to assign scale values to opinion statements, so as to determine their location on the evaluative continuum (Ajzen & Fishbein, 1980:15). Thurstone's scale included a laborious task of judging and calculating medians for the categories, which prompted a search for a simpler one. Rensis Likert developed his own scale, excluding the need for judges, and made it possible to have a typically five-point scale that can be administered directly to sample subjects or the population (Ajzen & Fishbein, 1980:16).

The two-dimensional view possesses two dimensions, each with its origin at neutral and extending into a 'positive' continuum or a 'negative' continuum. Attitudes then become a point on a plane, allowing for a number of negative elements and/or positive elements to be held simultaneously (Ajzen, 1988:20). Therefore, if an individual holds only negative elements, only positive elements or is neutral, the view can be collapsed into the one-dimension view (Maio & Haddock, 2010:34).

Furthermore, the two-dimensional view allows for attitudinal ambivalence, as both negative and positive elements can be held at equal quantum (Maio & Haddock, 2010:34). For example, an individual can dislike the killing and destruction associated with war, but equally like the liberating or peacekeeping effect of it. They therefore hold an ambivalent attitude towards war. The attitude structure views can be represented as follows:



**Figure 2: Attitude structure views**

Attitude function refers to the need or function fulfilled by attitudes (Maio & Haddock, 2010:38).

## 2.8. Defining behaviour

Behaviour, as defined by Miltenberger (2012) is “what people do and say”.

There needs to be a focus on the strict differentiation between behaviour and the outcomes of behaviours. Firstly, an outcome can be the aggregate effect of several behaviours. For example, success in sport (outcome) may be the result of a combination of practice, watching other sportspersons, using professional sportswear and kits when performing, and being trained by a successful sportsperson. Secondly, outcomes can be a result of the behaviours of others. For example, the strictness of sports judges in assessing performance and the dedication of the mentor to see improvement can also influence success. Thirdly, other extraneous factors can also influence the outcome. Examples are age, climatic conditions, and availability of training equipment, all of which are not linked to anyone’s’ behaviour. Once the distinction between behaviour and its outcomes has been made, then we can consider defining the behaviour criteria (Ajzen & Fishbein, 1980:29-30).

## **2.9. Behaviour modification**

Of particular importance to this study is the modification of behaviour for the desired outcome to be produced. Kazdin (2001:3) defines behaviour modification as “an approach to the assessment, evaluation, and alteration of behaviour.” Mikulas (1972:11) summarises it as being “generally a fast, efficient and relatively inexpensive way of dealing with behavioural problems”.

Authors on behaviour modification prescribe varying characteristics to behaviour modification, or at least, utilise different wording. These characteristics are important to note as they provide a criteria with which to ascertain as to what is behavioural modification and what is not. They also inform the methodology of this study, building from the definition of behaviour. Kazdin (2001:3-8) provides five key characteristics of behaviour modification. Firstly, it is that behaviour modification focuses on behaviour. While it may seem obvious, the point is that the focus is on overt behaviour, and not the full ambit of human functioning. Human functioning encompasses thoughts and feelings. The rationale behind focusing on overt behaviour is while an effective intervention on behaviour can affect thoughts and feelings, it is generally overt behaviour that prompts an intervention. In addition, assessment of the intervention’s effectiveness is through assessing behaviours that represent key areas of the problem. This is supported by Martin and Pear (1992:7); Sheldon (1982:39) and Miltenberger (2012:5). Miltenberger adds that there must be a de-emphasis on labelling (use of behavioural categories) and a focus on individual behaviours.

The second characteristic is a focus on current determinants of behaviour. Current behaviour can be greatly influenced by the past. For example, liver failure can be attributed to years of heavy drinking. Current emotional problems can be attributed to childhood abuse. Understanding the root cause is important in understanding the current condition and is beneficial in prevention, but behaviour modification focuses on what can be done now to influence behaviour and improve adaptive functioning. Mikulas (1972:10) supports that behaviour modification utilises an ahistorical approach.

The third characteristic identified by Kazdin (2001:-8) is that behaviour modification focuses on learning experiences to promote change. There is an assumption that special learning experiences can modify behaviour, as behaviour is plastic in nature, or rather malleable when subjected to systematic learning experiences. The emphasis on ‘special’ learning experiences is to emphasise that this learning needs to be systematically applied in very specific arrangements to ensure that the desired learning occurs and performance remains consistent.

Learning occurs all the time, through various media, but to ensure behaviour change, the interventions must be controlled.

The fourth characteristic is that the assessment and evaluation of the intervention is an important part of behaviour modification. As per the definition, behaviour modification includes both. A distinction must be drawn between the two, as they should not be considered as synonymous. Assessment is focused on identifying the behaviour and determining what the causal events are. Essentially, it is the determination of the goals of the intervention (Abrahamse, Steg, Vlek & Rothengatter, 2005:pp 287). In addition, as the intervention is implemented, assessment is done to determine if change is occurring and whether the outcomes are achieved or not. Evaluation is complementary but separate to assessment. Evaluation is concerned with making inferences on whether change has occurred, and whether this change can be attributed to the intervention (Abrahamse *et al.*, 2005:pp 287). It is through evaluation that the need to use another or alter the intervention used can be identified.

The fifth characteristic is that application of interventions should be possible in everyday life and settings. Professionals may design and prescribe the interventions, but the implementation of these interventions is generally by non- or paraprofessionals. These include teachers, parents, managers, relatives etc. Paraprofessionals work in concert with the professionals to achieve the behavioural change, but non-professionals work independently. Mikulas (1972:10-11) also notes that there is no need for a direct relationship between the behaviour modifier and the subject, and that a mediator can implement the behaviour, or the subject be trained to alter their own behaviour.

For the purposes of this study, this list of characteristics will be augmented with those suggested by Miltenberger (2012:5-7). The reason is that they summarise what other authors have also stated but Kazdin (2001) has excluded.

Mikulas (1972) suggests that for years the way in which psychological problems were dealt with was the medical model. This model, he adds, seeks to deal with the underlying cause of the manifest behaviour, and includes procedures such as psychoanalysis. He further adds that a major challenge with this approach is that the concepts used in the various theories do not have adequate functional definitions, and therefore cannot be measured accurately. The lack of adequate measurement raises concerns of applicability of the construct and its purported changes. The lack of measurement also means that it is difficult to predict behaviour, which is then addressed on a post hoc basis (Mikulas, 1972:4-5).

Mikulas (1972:5) suggests that another major problem with the medical model is that it is premised on the effectiveness of psychotherapy. This is due to it being time-consuming and expensive. Nevertheless, Mikulas (1972:6) concedes that psychotherapy might be efficient with certain problems. An alternative model to the medical model is one premised on behaviour being the focus of treatment, instead of the underlying causes. This is the behavioural model (Mikulas, 1972:6).

Behaviour modification, more formally known as applied behaviour analysis, is the field in social psychology aimed at altering behaviour, with the intent of increasing the occurrence of favourable behaviour and reducing or eradicating undesirable one.

## **2.10. Attitude-behaviour relationship**

The relationship between attitude and behaviour has been explained through different theories. This study will look at two of these theories, with the second being an augmented version of the first.

### **2.10.1. Theory of Reasoned Action and Theory of Planned Behaviour**

Fishbein and Ajzen (1975) originated the Theory of Reasoned Action (hereafter referred to as TRA). They posited that behaviour is directly influenced and is predicted by behavioural intention. This means that an individual behaves in a certain way because they intended to do so (Ajzen & Fishbein, 1980:5). The theory therefore assumes that behaviour has a level of deliberation, which is consistent with its title (Johnson, Boynton & James, 2010:27). The relation between behaviour and intention can be represented as follows

$$B \approx I$$

where  $B$  denotes overt behaviour and  $I$  the behavioural intention. In this domain, it is overt behaviour that is measured and generally through explicit measures (Albarracín, Johnson, Fishbein & Muellerleile, 2001:pp 143). Behavioural intention in turn has two determining factors, attitude and subjective norms. Attitude, in this instance, refers to an individual's attitude towards engaging in certain behaviour, whether they think it is good or bad (Maio & Haddock, 2010:68). This evaluation is usually measured on a bipolar scale (Albarracín *et al.*, 2001:pp 143). Subjective norms refers to the individual's perception of whether important others think they should or should not engage in the particular behaviour (Maio & Haddock, 2010:68). This relation can be represented as follows

$$I \approx A_{B_{w_1}} + SN_{B_{w_2}}$$

where  $I$  denotes the intention to engage in behaviour  $B$ ,  $A_B$  denotes the attitude towards engaging in behaviour  $B$ ,  $SN_B$  denotes the subjective norms associated with behaviour  $B$ , and

$w_1$  and  $w_2$  are weightings for  $A_B$  and  $SN_B$ , respectively. The weightings are important because the importance of one factor over the other varies from each individual to the next (Ajzen & Fishbein, 1980:6). The two determinant factors of intention also comprise of two determinant factors each. Attitude is determined by expectancy and value. Expectancy refers to an individual's expectation that engaging in certain behaviour will produce the desired outcome (Maio & Haddock, 2010:18). For example, the expectation can be that replacing incandescent bulbs will reduce electricity consumption. The second factor, value, refers to the evaluation of whether the desired outcome is good or bad (Maio & Haddock, 2010:18). For example, that reducing one's electricity consumption is a good thing. This attitude relation can be represented as follows

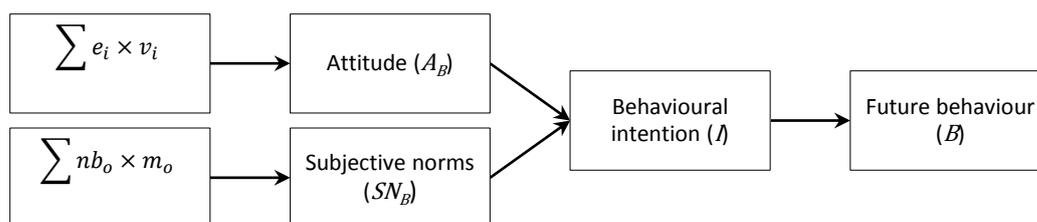
$$A_B \approx \sum_{i=1}^y e_i v_i$$

where  $A_B$  denotes the attitude towards engaging in behaviour  $B$ ,  $e_i$  denotes the strength of expectancy that engaging in behaviour  $B$  will result in outcome  $i$ ,  $v_i$  denotes the value attached to outcome  $i$  and  $y$  denotes the number of salient expectations (Albarracín *et al.*, 2001: pp 143). In short, an individual's attitude towards engaging in behaviour is the sum product of the expectancy ( $e$ ) values and their corresponding value ( $v$ ) values (Maio & Haddock, 2010:68).

Subjective norms are determined by normative beliefs and motivation. Normative beliefs refer to how an individual believes important others expect them to behave. For example, an individual can believe that their spouse expects them to reduce their electricity consumption. Motivation refers to the motivation to comply with these expectations. For example, there is possibly greater motivation to comply with a spouse than a friend, with them having the same expectation (Albarracín *et al.*, 2001: pp 143; Maio & Haddock, 2010:68). This subjective norm relation can be represented as follows

$$SN_B \approx \sum_{o=1}^z nb_o m_o$$

where  $SN_B$  denotes the subjective norm toward behaviour  $B$ ,  $nb_o$  denotes the normative belief held about important other  $o$ ,  $m_o$  denotes the motivation to comply with important other  $o$  and  $z$  denotes the number of salient important others (Albarracín *et al.*, 2001:pp 143). With all the model relations identified, the entire model can be represented as follows



**Figure 3: Model of the Theory of Reasoned Action**

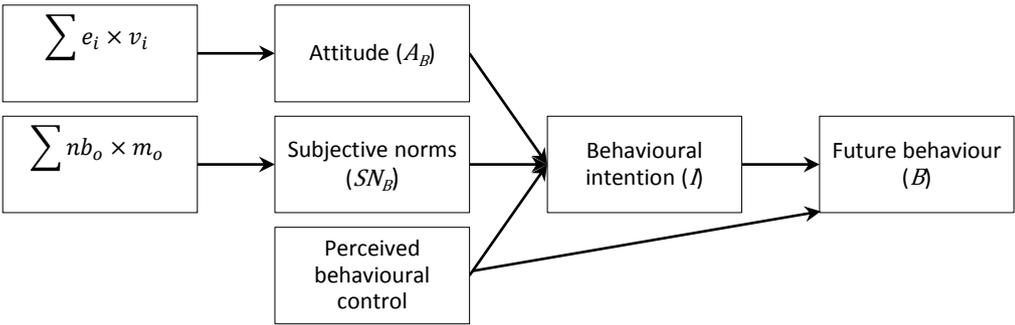
Not all intentions and subsequent attitudes are under volitional control (Albarracín *et al.*, 2001:pp 144), and so Ajzen augmented the TRA adding a fourth determining factor of intention, perceived behavioural control. The revised model was called the Theory of Planned Behaviour (hereafter referred to as TPB). Perceived behavioural control refers to how much control an individual thinks they have in engaging in certain behaviour, where control is defined as resources and opportunities required to engage in the behaviour (Maio & Haddock, 2010:69). It is the only factor determining intention ( $I$ ) that can also influence behaviour directly. The rationale behind this bypassing of the mediating factor, behavioural intention, is that if the perceived control is actually real control, then behaviour can be engaged in. However, if the perception reflects low confidence in the ability to control the behaviour, then the perceived control will influence intention (Maio & Haddock, 2010: 69). It must be added that perceptions can be incorrect and therefore not predict the behaviour (Albarracín *et al.*, 2001: pp 144; Maio & Haddock, 2010: 69). The revised relation of behavioural intention and its factors can be represented as follows

$$I \approx A_B + SN_B + PBC$$

where  $I$ ,  $A_B$  and  $SN_B$  are as previously defined and  $PBC$  denoted perceived behavioural control. Because perceived behavioural control can also influence behaviour directly, the revised relation of behaviour with its determinant factors can be represented as follows

$$B \approx I + PCB$$

where  $B$ ,  $I$  and  $PCB$  are as previously defined. Albarracín *et al.* (2001:pp 144) suggest that the perceived behavioural control is the aggregate of three factors: 1) one can or cannot perform the behaviour if one wants to, 2) performing the behaviour is not up to oneself, and 3) performing the behaviour is easy or difficult. Maio and Haddock (2010:69) collectively refer to these perceptions as control beliefs. The entire TPB model can be represented as follows



**Figure 4: Model of the Theory of Planned Behaviour**

The TRA and TPB model how attitudes influence behaviour. From this perspective, increasing desired behaviour, reducing, or eradicating undesired behaviour is a matter of changing attitudes.

However, there remains the issue of how behaviour can influence attitudes. Considering smoking as an example, a smoker can engage in smoking due to a favourable intention, but due to undesirable outcomes (monetary expenditure, increase in health risks and social exclusion), decide to quit. However, when they realise that is quitting is more difficult than originally anticipated they change their beliefs.

## **2.11. Behaviour change strategies: intervention design and implementation**

The following will be a discussion of the classification of behaviour change strategies. This will include a discussion of how the individual interventions are implemented and where they are most efficacious.

### **2.11.1. Curtailment versus efficiency behaviours**

Behaviours targeted by interventions are commonly classified as two types: curtailment behaviour and efficiency behaviour (Boudet, Flora & Armel, 2016:pp 445; Gardner & Stern, 1996; Karlin, Davis, Sanguinetti, Gamble, Kirkby & Stokols, 2014:pp 425). Curtailment behaviours require repetition to be impactful in a meaningful way, usually entail the reduced use of an amenity and expenditure is low or non-existent when it comes to doing them. Efficiency behaviours are single, structural behaviours that by virtue of implementation promise present and future benefit. Since they are usually implemented through technology, there is an expense involved. Boudet *et al.* (2016) make a case for broader classifications instead of this two-dimensional one, stating that a broader classification allows for greater efficacy of interventions, an idea supported by many other researchers (Karlin *et al.*, 2014:pp 430 - 431). Cunningham, Galloway-Williams and Geller (2010:pp 408-409), however, suggest that this two-dimensional approach assists in identifying the behaviours with the greatest potential for impact, which are efficiency behaviours. They do lament that current literature indicates a propensity towards targeting curtailment behaviour (Abrahamse *et al.*, 2005:pp 274). De Nardo, Brooks, Klinsky and Wilson (2017) argue that although efficiency behaviour has the greater impact in many scenarios, curtailment behaviour, in certain instances, actually has the greater impact. For example, those who utilise public transport have greater impact than if they all bought electric/hybrid vehicles. There seems to be value in considering a broader classification of behaviour. However, this study will be limited to the dichotomous classification.

Another noteworthy point is that the case for targeting efficiency behaviour holds if the individual has the ability, means and/or control to do so. Those with means can absorb the cost of new technologies and 'green' products. Tenants have no control over fittings installed by developers of rental units. Students have no control over luminaire choices, the use of passive design strategies or other technologies employed in residences. Targeting efficiency

behaviour is therefore not possible in all contexts as not everyone has a chance to engage in these behaviours, as not everyone can engage in 'design for sustainability'. For the many individuals who have predetermined spaces of living, working and/learning imposed on them by the powers that be, targeting curtailment behaviour is the only option they have in contributing to ecological sustainability.

Engaging in efficiency behaviours have been associated with enhanced social status, yet little evidence exists that social status can be enhanced by curtailment behaviour. A possible explanation is that social signalling suggests that efficiency behaviour indicates a choice driven by concern for the environment, while curtailment behaviour indicates necessity to do so due to lower income (De Nardo *et al.*, 2017:pp 185). Boudet *et al.* (2016:pp 445) question the substantive validity of the social signals, stating that research suggests that curtailment behaviours are influenced more by environmental concern than efficiency ones. They further argue that curtailment behaviour may be considered as having less impact, but has the greater potential for behaviour change. The repetitive nature allows for habit formation. De Nardo *et al.* (2017:pp 186) concur by stating that behaviour change is more important, as it tackles the issue of consumerism.

The context of this study is already established university residences, wherein the occupants cannot engage in any efficiency behaviour. The transient nature of occupancy leaves no room for structural impact. Occupants can only be wary of their own use of utilities. This study will therefore focus on interventions targeting curtailment behaviour. The behaviour in question is the reduced consumption of water and electricity.

### **2.11.2. Intervention classifications**

Steg and Vlek (2009) suggest two approaches of classifying strategies for behaviour change. The first approach distinguishes between antecedent and consequence strategies. Antecedent strategies are aimed at influencing the factors preceding behaviour. Examples include information, prompting, modelling and commitments. Consequence strategies are aimed at changing the consequences subsequent to the behaviour being performed. Examples of these are incentives, feedback and penalties.

The second approach of classifying strategies is that of distinguishing between informational strategies and structural strategies. Informational strategies are aimed at changing "prevalent motivations, perceptions, cognitions and norms" (Steg & Vlek, 2009:pp 313). Structural strategies are aimed at altering the prevailing conditions to facilitate preferred behaviour taking place. Considering interventions under the information/structural distinction allows us to select

interventions that will target curtailment behaviour as opposed to efficiency behaviour. Since the target group has no ability to change the prevailing conditions, this study will focus on informational strategies. Information strategies consists of both antecedent and consequence strategies.

### **2.11.3. Informational strategies**

Drawing from Steg and Vlek (2009), Steg, Berg and De Groot (2013:225-229) state that five common informational strategies are information provision, commitment, goal setting, prompting and feedback. Other interventions such as modelling will not be discussed. Information provision assumes a knowledge deficit, either in understanding the problem at hand or in understanding how to address it. Steg and Vlek (2009:pp 313) state that information provision assumes that an increase in knowledge will result in attitude changes, which will in turn influence behaviour. This strategy has not been very effective on its own. Efficacy has been improved in tailoring information for the target audience (Abrahamse, Steg, Vlek & Rothengatter, 2007:pp 266) and by providing normative information, which is the opinion or behaviour of others in the same situation.

Commitment techniques are centred on binding oneself to change a behaviour through an oral or signed pledge or promise (Abrahamse *et al.*, 2005:275). Steg and Vlek (2009:pp 313) suggest that commitment strategies are efficacious in encouraging pro-environmental behaviour. When commitments are made in public or have the potential to be publicised, efficacy increases. Reasons posited for this effect include salience of associated behaviours, attitudes and beliefs; a propensity to conform to publicly held attitudes as opposed to private one; and the effects of social pressure in making one stick to their commitment. Commitment is regularly coupled with other strategies like goal-setting and incentives (Steg *et al.*, 2013:227).

Goal setting is giving a household a goal in terms of a target decrease in the use of a utility. For example, the goal may be set at 10% reduction, premised on goal theory, which suggests that behaviour is goal orientated.

Prompting makes use of cues in the form of short messages or signs to elicit a certain behaviour in a specific situation in the presence of a discriminative stimulus. For example, messages around littering are placed near bins and ones on conserving electricity are placed beside light switches (Steg *et al.*, 2013:228). Miltenberger (2012:179) suggests that prompts are about maximising the probability of the subject engaging in the desired behaviour. This behaviour is then reinforced through some incentive to ensure continuity. Miltenberger

(2012:180) further suggests that once the desired behaviour has been achieved, fading needs to be implemented. Fading is the incremental removal of a prompt to ensure that the desired behaviour is elicited in the presence of the discriminative stimulus. For example, the prompt may be a message by a light switch, reminding tenants to turn off lights as they leave. The reinforcement may be praise when the behaviour is explicitly observed or when reduced electricity usage is observed. The gradual removal (fading) of the prompts by the light switches (discriminative stimuli) needs to be done, to ensure that when the subjects see a light switch, they behave accordingly of their own accord. Steg and Vlek (2009) suggest that prompts are effective in bringing about behaviour change.

Sussman and Gifford (2012) evaluated the effectiveness of visual prompts in encouraging people to turn off lights in unused washrooms. The results indicated that lights were turned off eight times more frequently in washrooms that had 'lights off' signs than those without. Tetlow *et al.* (2014) conducted a similar study, focusing on whether visual prompts would improve the probability of lights being switched off after meetings. Their results indicated that the visual prompts significantly increased the probability of the lights being switched off. Bergquist and Nilsson (2016) state that prompts have been used to reduce littering, promote recycling and improve energy conservation. Their study investigated whether or not using normative prompts would increase turning off lights at public bathrooms. Their results reflected a 16.2% increase in pro-environmental behaviours (turning lights off) when prompts were used.

Feedback is providing information to people on their performance of a specific behaviour. This can be done with a frequency ranging from continuous, using smart meters, to monthly, which is the most common upper limit when it comes to frequency. The efficacy of feedback as a strategy lies in highlighting the causal links between a desired outcome and the behaviour required to achieve it (Steg *et al.*, 2013:228-229). In their analysis of residential energy conservation, Karlin *et al.* (2014) conclude that feedback is a universally effective strategy. Abrahamse *et al.* (2005) concur, with the results of their review of interventions indicating that in most studies, feedback was an effective intervention. They add that the more frequent the feedback, the better the results.

#### **2.11.4. Combining interventions**

There is much evidence suggesting that efficacy of interventions is increased by combining two or more. Sintov, Dux, Tran and Orosz (2016) used feedback, incentives, information and prompts in a competition framework that saw an average 6.4% reduction in energy consumption relative to baseline in a college dormitory. Konis, Orosz and Sintov (2016) conducted a similar competition at a university dormitory, utilising the same combination of

interventions. They recorded a 12% reduction in energy consumption during the competition phase and 13% beyond it, when all incentives had ended. Petersen, Shunturov, Janda, Platt and Weinberger (2007) achieved a 32% reduction in electricity use and 3% reduction in water using feedback, incentives and information provision.

A national university dormitory competition that utilised feedback and incentives resulted in statistically significant reductions in water and electricity consumption in the various institutions (Petersen, Frantz, Shammin, Yanisch, Tincknell & Myers, 2015).

### **2.11.5. Designing and placing prompts**

Research suggests that including pictures in prompts makes them more effective (Sussman & Gifford, 2012:pp 597). This study will utilise posters with pictures as well, dependant on the message being given.

Bergquist and Nilsson (2016) used four types of prompts – single injunctive: prescriptive, single injunctive: proscriptive, dual injunctive: prescriptive picture and proscriptive text, and dual injunctive: proscriptive picture and prescriptive text – to investigate the effects of framing. An injunctive is a behavioural command (Bergquist & Nilsson, 2016:pp 24). Prompts framed prescriptively suggest what the participant ought to do, and therefore are perceived to be positive. On the other hand, prompts framed proscriptively indicate what the participant should refrain from doing, making them seem negative (Bergquist & Nilsson, 2016: pp 25). The results of this study indicate that prompts framed with both prescriptive and proscriptive content are the most effective (Bergquist & Nilsson, 2016:pp 30).

Sussman and Gifford (2012:pp 597) suggest that prompts should be placed in proximity with where the behaviour is going to be conducted. A prompt that is read immediately before the opportunity to engage in the behaviour is more efficacious than one read earlier. This study will utilise posters placed by the washrooms, lifts and ablutions facilities.

### **2.12. Conclusion**

The literature is clear in that we need to reduce our consumption of water and electricity. These resources affect many areas of our lives. Potable water, unlike electricity, is a scarce natural resource. What the literature also makes clear is that human behaviour is the cause but can also be a solution to the ecological crises we face.

Behaviour can be modified with various interventions. These interventions do not target the overt behaviour itself but seek to influence the determinants of behaviour. People need to be

taught about what the problem is and what can be done to fix it. However, this information alone is not enough, because the attitudes that indirectly influence our behaviour are made up of more than just cognitive information. We need information to be designed and presented in a manner that speaks to the affect of people, as affect is the most important influence of behaviour.

One way of doing this is through prompts that are framed correctly, in that they tell the reader what to do and/or what not to do. These prompts need to be located strategically, at the point of decision. This study will utilise prompts in the form of posters with pictures and words. These will be placed within the residences targeting the ablution facilities, lifts and washrooms. These are places of decision, or en-route places of decision. These prompts are designed to inform and instruct the reader. The information is facts about water and electricity use, with a particular emphasis on quantity. The instructions are pragmatic ways on how an individual can reduce their consumption.

## **CHAPTER 3 - RESEARCH DESIGN AND METHODOLOGY**

### **3.1. Introduction**

This chapter will briefly discuss the research problem and the associated research questions. The research strategy will be discussed, as well as the methodology for data collection and analysis. The sampling method will be discussed briefly, indicating the rationale behind its selection. The assumptions, limitations and delimitations for this study will also then be stated.

### **3.2. Problem statement and research question**

#### **3.2.1. Problem statement**

The problem is how to get people to change their behaviour regarding water and electricity usage.

#### **3.2.2. Research question**

How effective is a passive intervention in reducing water and electricity consumption in the University of Pretoria's Groenkloof female residences?

The research question will be broken down into the following sub-research questions:

- a) Sub-research question 1: What is behaviour change and what interventions exist to bring about behaviour change, both active and passive?
- b) Sub-research question 2: Did the passive intervention reduce water and electricity consumption in the residences?

### **3.3. Research Strategy**

The study aimed to evaluate the effectiveness of a passive intervention in reducing the consumption of water and electricity by university students in residences. This intervention took the form of posters on all floors, in the ablutions, wash rooms and by the lifts, giving facts on water and electricity consumption, and how both can be reduced (see Appendix A). These were left in place for the duration of the observation period and were not changed, in terms of location and/or message.

To implement the interventions in a comparable manner, randomisation could not be employed, as there were few residences with similar characteristics. The study thus employed a quasi-experimental approach (this is explained in the section on sampling). One residence, Inca, was the control, while the passive intervention was implemented at Liliun and Zinnia.

### **3.4. Methodology**

There are both quantitative and qualitative components to the study. This is to obtain different data, which allows for a more robust inferential/interpretative basis. The study therefore utilised a mixed method approach. The mixed method approach has a core and a supplementary component. In this study, the quantitative component was the core and the qualitative component was supplementary.

Qualitative research allows research to produce findings not arrived at through statistical procedures and other methods of quantification. It facilitates research in persons' lives, behaviours and emotions, among other things. Although the data may be quantified in its collection, the analysis is primarily interpretative (Strauss & Corbin, 1998:10-11).

One method to conduct qualitative research is through active interviewing. Interviewing asks people to talk out their lives, ranging from "highly structured, standardised quantitatively orientated survey interviews, to semi-formal guided conversations and free-flowing informational exchanges" (Holstein & Gubrium, 2002:112). All are used to produce empirical data about the social world (Holstein & Gubrium, 2002:112). This study utilised interviews in the focus group format to understand the underlying dynamics at work regarding the interventions and to gain information for subsequent research. Holstein and Gubrium (2002:119) state that where respondents are engaged as active subjects, they transform from just repositories of reasons, emotions and opinions into productive sources of knowledge. The focus groups were conducted in an interpersonal manner, not to dictate interpretation but to construct a space conducive for diverse meaning, also varying in complexity (Holstein & Gubrium 2002, p.121).

Quantitative research was limited to data obtained from the Department of Facilities Management. These were meter reading for both water and electricity for the three residences for the years 2014 through to 2016. Readings for 2017 were not available to include in the study due to technical issues. These would have provided the basis for a post-intervention analysis.

#### **3.4.1. Poster design and placement**

Fourteen posters with different messages were designed for this study. The messages used were adapted from tips on to the City of Cape Town and Water Wise websites. All these messages were framed prescriptively. Each poster was printed in colour, on A4 size paper and laminated to ensure durability. The residences have 12 floors above the ground floor that follow

a typical layout, with two wings on either side of a circulation core. Each floor has two ablution facilities, one in each wing, and each floor has one washroom. The western wing's ablution facility has the following: four water closets (toilets), one shower, two bathtubs and four wash hand basins (sinks). The eastern wing's ablution facility has the following: three water closets (toilets), one shower, two bathtubs and five wash hand basins (sinks). Each washroom has one washing machine, one dryer and two wash troughs.

The posters were put up in the residences in the following areas: elevator lobbies, washrooms (laundry rooms) and ablution facilities. Figure 5 illustrates the in-situ placement of posters. The elevator lobbies are located in the circulation core, adjacent to the stairwells. This makes them a suitable place for the general messages like reminding residents to turn off their room lights and turn off their appliances when they leave. It was not feasible to provide each resident with both posters for their room, so the elevator lobby was selected for this purpose. These two posters were placed adjacent to the elevator control panel. Where this was not possible, especially where the specific floor has put up their own posters or artwork around the panel, they were placed as close to the elevator doors as possible.



Posters addressing wash hand basins put up adjacent mirrors in Zinnia.



Posters addressing showers put up in change space in shower enclosure in Zinnia.

**Figure 5: Examples of in-situ placement of posters**

For the washrooms (laundry rooms), two posters were put up. One addressed the use of the washing machines, and it was placed above on the wall behind the machines. The second addressed turning off the lights when the washroom is not in use. It was placed adjacent to the switch, which is conveniently by the door.

In the ablution facilities, posters referring to water closets were placed on the internal side of the door, alternating the messages. Posters referring to wash hand basins were placed between the mirrors above them, alternating the messages. Posters referring to bathtubs were placed on the wall parallel to the bathtub at eye level, ensuring maximum visibility to anyone approaching the bathtub. Posters referring to showers were placed beside the mirrors within the shower space.

### **3.4.2. Data collection**

Electricity and water meter readings were obtained from the Department of Facilities Management on a quarterly basis. Each residence has a bulk water and electricity meter, and readings show month-on-month variances as a cumulative year reading, among others. The quarterly publishing of the results means that residence sessions could not be conducted where the readings are discussed, as with the change of seasons, proposed utility saving strategies became less relevant.

The qualitative part of the investigation utilised focus groups interviews as a data collection tool. From each of the residences, a random selection of the residents was made, with the attempt to get groups that cut across the demographics of race and age. The focus groups were conducted with pre-prepared questions (see Annexure B), which were adapted for each residence's unique circumstances, if the need arose. The participants were be briefed on the purpose of the focus group, how the data were to be collected and analysed, and on the protection of their identities.

Each residence had one session that was maximum one and a half hours long. Groups were limited to 10 participants. This was to ensure maximum participation. These sessions were recorded so that responses can be transcribed verbatim, for analysis purposes.

### **3.4.3. Data analysis**

The quantitative data obtained from the Department of Facilities Management was ratio scale data, which is generally suitable for extensive mathematical and statistical analysis. To determine if there could be a statistically significant causal relationship between the administration of the intervention and the reported meter reading, a 'paired samples t-test' was conducted for only the Zinnia and Liliun meter readings. Due to the homogeneity of the two residences, they were be treated as a single group. This is why the ANOVA was not considered for this analysis. The 2014 readings (base year) were compared with the 2016 readings (intervention year).

A 'paired samples t-test' is a parametric analysis is suitable for ratio scale data, and is more powerful than the non-parametric alternatives. IBM SPSS 24 was used to run these analyses. Factor analysis, internal validity testing and testing for occasions reliability (external validity) were not conducted in this study.

For the data that was obtained from the focus groups, no statistical analyses were conducted. This data were used to understand the quantitative data better, as the participants' lived

experience provided the background to its interpretation. Responses obtained from the focus groups were recorded verbatim, and responses to each question summarised. All the questions were open-ended, with the intent to elicit varied responses and promote dialogue.

The data were analysed to provide information to understand how the intervention affected the participants' behaviour, what their perceptions of the issues surrounding water and electricity usage are, and to obtain suggestions on how the intervention could be bettered for future studies.

### **3.5. Sampling**

The University of Pretoria has 28 residences. These residences are spread out geographically, are undergraduate or postgraduate, and are single-sex or mixed-sex, among other factors. Since the study focuses on consumption patterns, the residences to which the interventions were applied were in the same location, design, occupancy levels, occupancy demographics and have utilities measured individually. Of the 28 residences, the Department of Facilities Management advised that the three female residences at the Groenkloof campus, namely Inca, Lilium and Zinnia, were the most suitable, when considering feasibility of the study. Through this process of elimination, these three residences became the population.

For the focus groups, convenience sampling was used. The students eligible to participate were those present in 2016, which means that 2017's first years were excluded. The residence directors and their management committees were approached to assist in the selection of 10 participants for each focus group. As students write semester tests, do assignments and begin with examinations at varying times, the first 10 respondents to the management committees' invitation formed the focus group. Invitations were made via social media and word of mouth.

### **3.6. Assumptions, limitations and delimitations**

#### **3.6.1. Assumptions**

The researcher has made the following assumptions:

- Occupancy of residences will be at 100% throughout the academic year, notwithstanding residents moving out and new residents moving in during the year
- No water-saving and/or electricity-saving devices will be installed during the observation period, and all strategies for reducing consumption of utilities will be applied uniformly by the University.

- Meter readings obtained from the University of Pretoria's Department of Facilities Management are a true reflection of water and electricity consumption in the respective residences.
- Participants in the focus groups will be residents for the full year in 2016 and will be exposed to the various posters as they will use most if not all the residence amenities.
- Participants in the focus groups will answer questions honestly and candidly.

### **3.6.2. Limitations**

The following limitations are applicable in this study:

- Only three residences, namely Inca, Liliam and Zinnia, could be used for the study. These were the closest to homogenous as the researcher could get, for comparative purposes. There are other residences, but they are unique (making comparisons impossible) or the strategy of metering utilities does not provide the data required.
- Only female residences were used. Although Kiaat, the male residence at the Groenkloof campus, has similar characteristics, Kiaat's water supplies the adjacent dining hall. For that reason, the researcher excluded it.
- The residences used in this study are all located on the Groenkloof campus of the University. It is therefore not possible to observe the effects of the interventions in other climates/microclimates.
- All the residences in this study are tall buildings, with some residents facing north and others south. Responses elicited will be based on the resident's location.
- Data obtained were skewed by the national 'Fees Must Fall' protests. The protests influenced how many hours students spent in the residences, their level of activity in residences and the number days spent in the residence (as some decided to go home during this period).

### **3.6.3. Delimitations**

The following delimitations are applicable to this study:

- The observation period was from February 2016 to November 2016. This period was influenced by the University's academic calendar and was aimed at covering as many seasons as possible.
- The study was conducted only at the University of Pretoria, and the residences used were those owned and run by the University. This ensured uniformity in meter reading data, and that any policies and measures regarding use of utilities were applicable to all subject residences.

- Only three residences were used, as their homogeneity allows comparisons to be made.

### **3.7. Conclusion**

The passive intervention used in this study was posters, and these were put up in Liliun and Zinnia, while Inca was used as a control subject. These are the three female residences located at the University's Groenkloof campus. Kiaat, the male residence at Groenkloof, was excluded from the study as it shares its utilities with the adjacent dining hall.

Water and electricity meter readings were used and compared to historical records to establish if there has been an improvement. Focus groups were conducted to get a better understanding of the effect of the intervention with relation to behaviour change and information for future studies.

## CHAPTER 4 - RESULTS

### 4.1. Introduction

The results of this study were in the form of meter readings obtained from the Department of Facilities Management. The electricity usage readings were captured at the beginning of every month and reflect an accurate report of its consumption in the residences without the need of processing. They are reflected as received. The water usage readings were captured at intermittent intervals and necessitated some adjustment so that they would be comparable. They are reflected after being adjusted.

### 4.2. Tabulated meter readings of electricity and water consumption

Tables of the consolidated meter readings, for both electricity and water, are displayed below. Simple descriptive statistics have been used to provide better understanding of the data.

#### 4.2.1. Electricity meter readings

Table 1: Monthly electricity usage for 2014 (in kWh)

2014	Zinnia	Inca	Lilium	Total	Average
Feb	51 086	<b>54 781</b>	51 416	157 283	52 427.67
Mar	57 660	<b>58 978</b>	58 697	175 335	58 445.00
Apr	54 910	<b>57 986</b>	55 892	168 788	56 262.67
May	84 178	87 874	<b>92 393</b>	264 445	88 148.33
Jun	80 850	78 968	<b>89 029</b>	248 847	82 949.00
Jul	57 724	50 646	<b>60 007</b>	168 377	56 125.67
Aug	90 319	92 158	<b>103 028</b>	285 505	95 168.33
Sep	62 101	67 033	<b>67 324</b>	196 458	65 486.00
Oct	59 478	62 071	<b>62 888</b>	184 437	61 479.00
Nov	55 214	58 064	<b>61 041</b>	174 319	58 106.33
Total	653 520	668 559	<b>701 715</b>		
Average (month)	65 352.00	66 855.90	<b>70 171.50</b>		

\***bold** text indicates the highest value in a set

**Table 2: Monthly electricity usage for 2015 (in kWh)**

<b>2015</b>	Zinnia	Inca	Lilium	Total	Average
Feb	38 095	<b>48 030</b>	44 923	131 048	43 682.67
Mar	56 939	<b>65 309</b>	62 172	184 420	61 473.33
Apr	39 146	<b>50 650</b>	48 020	137 816	45 938.67
May	62 308	78 127	<b>78 306</b>	218 741	72 913.67
Jun	82 050	99 192	<b>103 324</b>	284 566	94 855.33
Jul	64 010	81 557	<b>83 622</b>	229 189	76 396.33
Aug	66 471	<b>81 743</b>	81 711	229 925	76 641.67
Sep	62 712	<b>78 064</b>	74 387	215 163	71 721.00
Oct	42 385	<b>58 629</b>	28 113	129 127	43 042.17
Nov	42 385	<b>58 629</b>	28 113	129 127	43 042.17
Total	556 501	<b>699 930</b>	632 690		
Average (month)	55 650.10	<b>69 993.00</b>	63 269.00		

\***bold** text indicates the highest value in a set

**Table 3: Monthly electricity usage for 2016 (in kWh)**

<b>2016</b>	Zinnia	Inca	Lilium	Total	Average
Feb	39 679	<b>56 430</b>	50 733	146 842	48 947.33
Mar	37 594	<b>49 136</b>	44 705	131 435	43 811.67
Apr	55 454	71 796	<b>74 594</b>	201 844	67 281.33
May	71 830	84 714	<b>97 976</b>	254 520	84 840.00
Jun	86 369	102 954	<b>119 861</b>	309 184	103 061.33
Jul	53 247	59 966	<b>75 837</b>	189 050	63 016.67
Aug	88 527	109 300	<b>133 460</b>	331 287	110 429.00
Sep	59 408	74 903	<b>87 027</b>	221 338	73 779.33
Oct	42 888	58 878	<b>69 714</b>	171 480	57 160.00
Nov	34 292	45 053	<b>51 330</b>	130 675	43 558.33
Total	569 288	713 130	<b>805 237</b>		
Average (month)	56 928.80	71 313.00	<b>80 523.70</b>		

\***bold** text indicates the highest value in a set

## 4.2.2. Water meter readings

**Table 4: Monthly water usage for 2014 (in m<sup>3</sup>)**

<b>2014</b>	Zinnia	Inca	Lilium	Total	Average
Feb	<b>1 493</b>	1 471	1 376	4 340	1 446.71
Mar	<b>1 613</b>	1 542	1 444	4 599	1 533.00
Apr	<b>1 418</b>	1 291	1 234	3 943	1 314.33
May	<b>1 410</b>	1 396	1 331	4 137	1 379.00
Jun	<b>1 460</b>	1 346	1 386	4 192	1 397.33
Jul	847	812	<b>851</b>	2 510	836.67
Aug	<b>1 777</b>	1 740	1 702	5 219	1 739.67
Sep	1 668	<b>2 043</b>	1 642	5 353	1 784.33
Oct	1 365	931	<b>1 381</b>	3 677	1 225.67
Nov	<b>1 679</b>	1 634	1 536	4 849	1 616.33
Total	<b>14 730</b>	14 206	13 883		
Average (month)	<b>1 473.00</b>	1 420.60	1 388.31		

\***bold** text indicates the highest value in a set

**Table 5: Monthly water usage for 2015 (in m<sup>3</sup>)**

<b>2015</b>	Zinnia	Inca	Lilium	Total	Average
Feb	1 705	1 607	<b>1 728</b>	5 040	1 680.00
Mar	1 167	<b>1 844</b>	1 323	4 334	1 444.60
Apr	<b>1 511</b>	1 324	977	3 812	1 270.67
May	1 236	<b>2 071</b>	1 494	4 801	1 600.26
Jun	627	1 262	<b>1 313</b>	3 202	1 067.17
Jul	<b>1 685</b>	872	720	3 277	1 092.33
Aug	1 355	<b>1 938</b>	1 818	5 111	1 703.80
Sep	1 227	<b>1 605</b>	1 445	4 277	1 425.67
Oct	1 157	<b>1 449</b>	1 403	4 009	1 336.33
Nov	538	1 334	<b>1 347</b>	3 219	1 073.03
Total	12 208	<b>15 306</b>	13 568		
Average (month)	1 220.80	<b>1 530.60</b>	1 356.76		

\***bold** text indicates the highest value in a set

**Table 6: Monthly water usage for 2016 (in m<sup>3</sup>)**

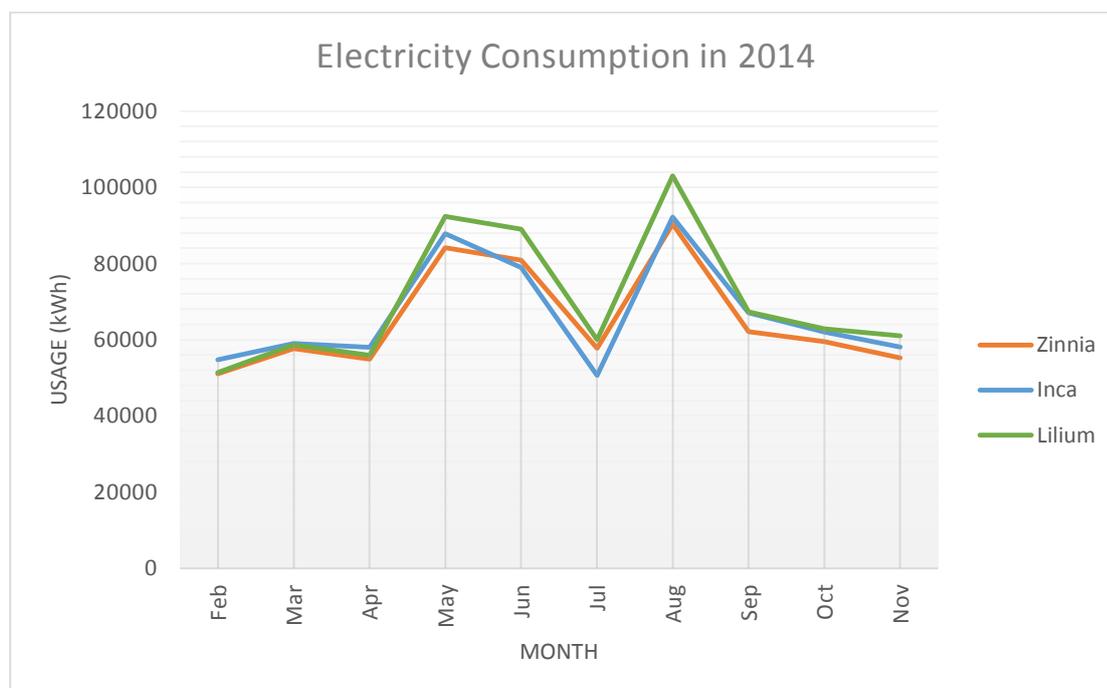
<b>2016</b>	Zinnia	Inca	Lilium	Total	Average
Feb	980	<b>1 518</b>	1 376	3 874	1 291.38
Mar	<b>1 609</b>	1 126	993	3 728	1 242.63
Apr	<b>2 694</b>	1 676	1 588	5 958	1 985.98
May	0	<b>1 493</b>	1 353	2 846	948.60
Jun	1 060	<b>1 625</b>	1 426	4 111	1 370.33
Jul	<b>1 355</b>	799	720	2 874	958.00
Aug	1 571	<b>2 033</b>	1 715	5 319	1 772.85
Sep	1 077	<b>1 285</b>	1 632	3 994	1 331.33
Oct	958	<b>1 110</b>	1 091	3 159	1 052.88
Nov	394	<b>1 002</b>	1 041	2 437	812.33
Total	11 698	<b>13 667</b>	12 934		
Average (month)	1 169.80	<b>1 366.70</b>	1 293.40		

\***bold** text indicates the highest value in a set

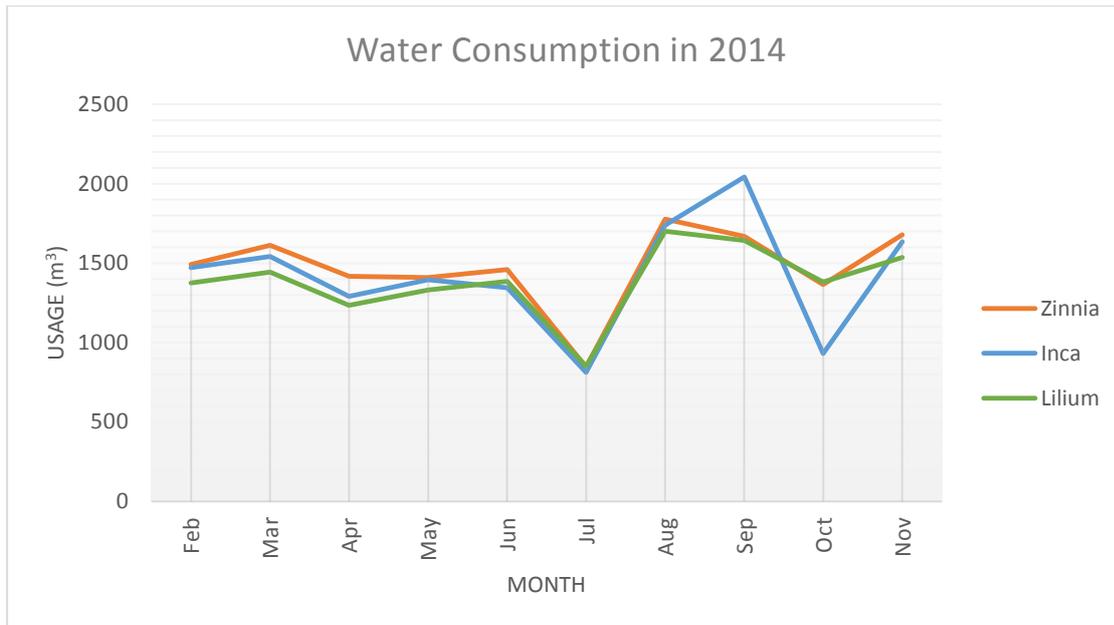
### 4.3. Graphic representation of electricity and water consumption

#### 4.3.1. Comparison of residences against each other

The line charts indicating electricity consumption and line charts indicating water consumption, between February and November for 2014, 2015 and 2016 comparing the residences against each other are as follows:



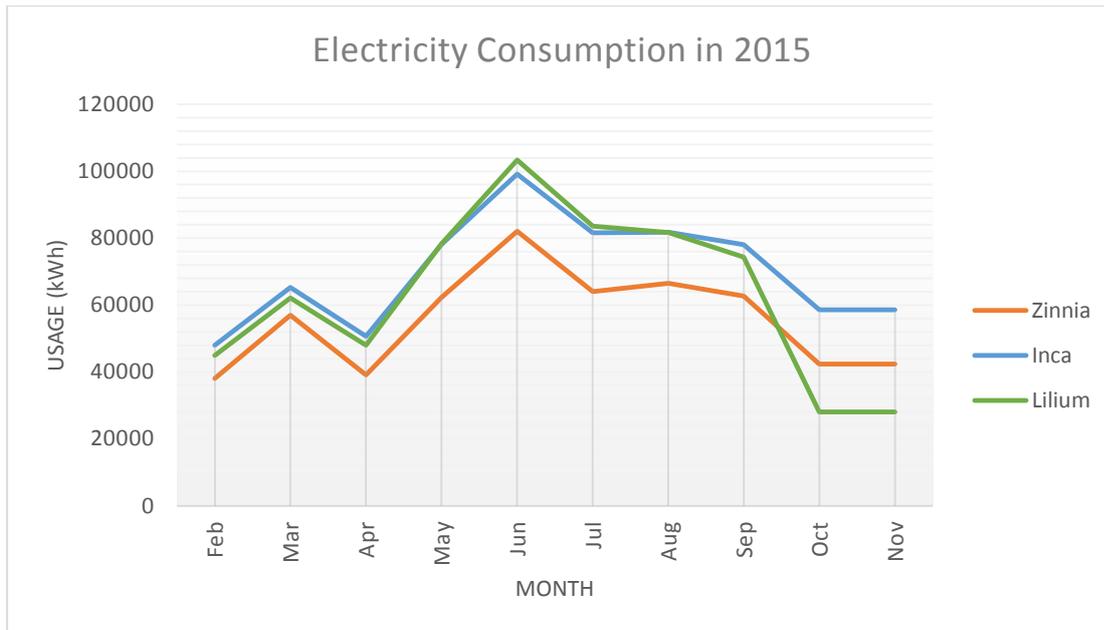
**Figure 6: Electricity consumption in the three female residences in 2014**



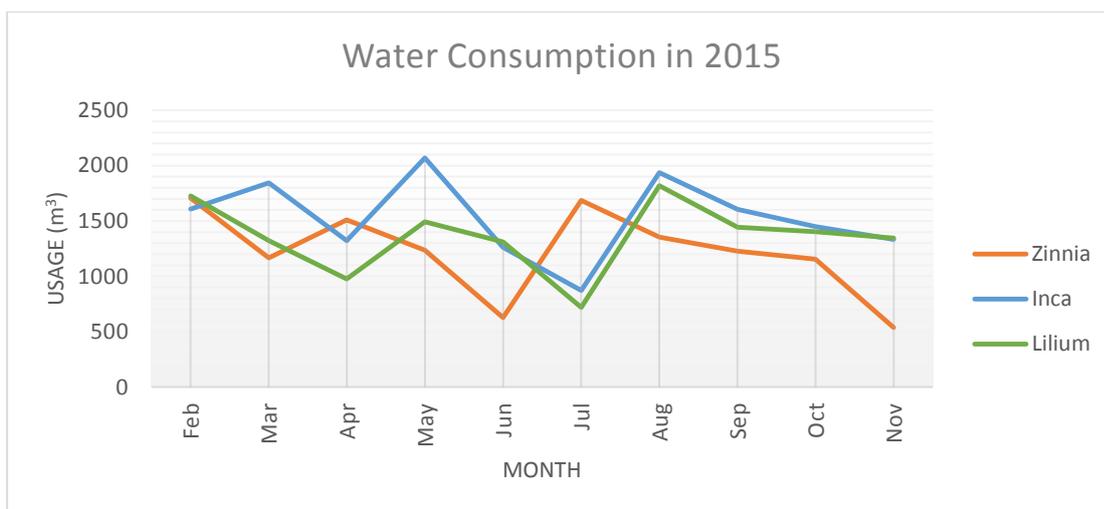
**Figure 7: Water consumption in the three female residences in 2014**

The baseline year is 2014 as student politics were not rife to skew the consumption patterns at the residences. The rationale of using readings from February to October was to cover the occupation period as per the academic calendar and to reflect consumption across seasons. The South African Weather Service (2017) states that in the southern hemisphere, 1 March to 31 May is autumn, 1 June to 31 August is winter, 1 September to 30 November is Spring and 1 December to 28/29 February is summer. The observation period of this study covers the last third of summer, and the other seasons fully.

The line chart for electricity consumption indicates spikes during the autumn/winter period, and relatively stable consumption for the rest of the academic year. It would have been expected that the line chart would have a sharp decrease around July, which coincides with the University of Pretoria's recess. This may be indicative of public lighting and room lighting remaining on during the recess. The line chart for water consumption indicates a sharp decrease in July, which coincides with the University of Pretoria's recess.



**Figure 8: Electricity consumption in the three female residences in 2015**



**Figure 9: Water consumption in the three female residences in 2015**

In 2015, the University of Pretoria experienced the beginning of major disruptions of the academic year by the ‘Fees Must Fall’ movement that became a nationwide crisis. The University of Pretoria responded by allowing limited access to campus, or by totally denying it. This meant that students spent more time in residences. It must be noted that this would be applicable to students studying at the Hatfield and satellite campuses, and not the Groenkloof campus. For the duration of the unrest, the Groenkloof campus remained relatively unaffected, except October when classes were cancelled intermittently.

The high consumption of electricity in July and relatively low consumption in October and November for all the residences does not follow the baseline pattern of consumption, but

indicates effects of students spending more time in residences and later in the year, many deciding to go home as classes were cancelled. The line chart for water consumption likewise reflects the effects of the student protests and University of Pretoria's decisions regarding students.

Aggregated year-on-year electricity consumption reduced by 6.65% from baseline in 2015. Water consumption reduced by 4.08% from baseline in the same year.

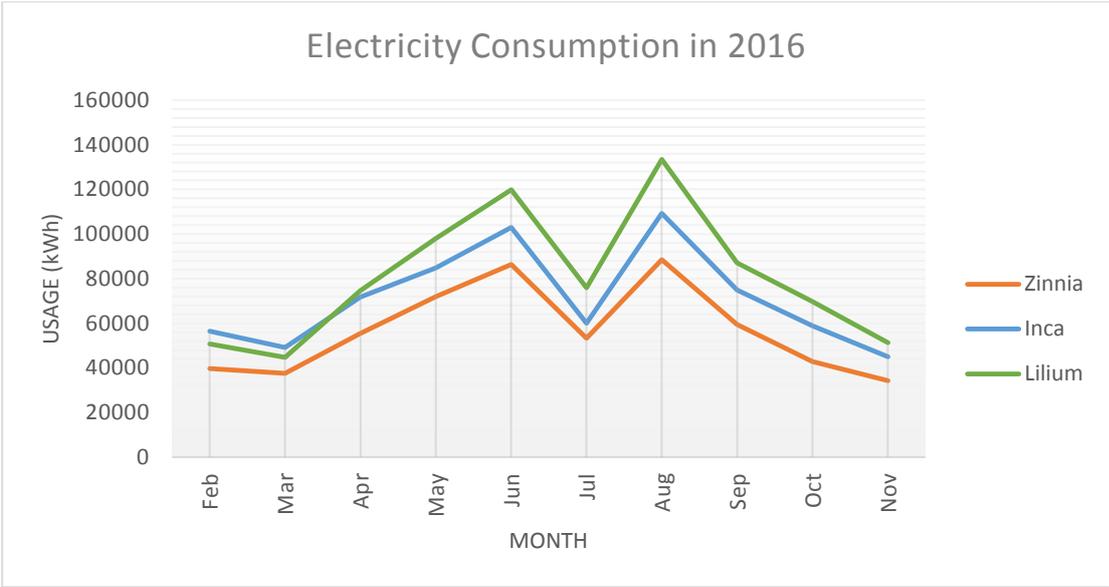


Figure 10: Electricity consumption in the three female residences in 2016

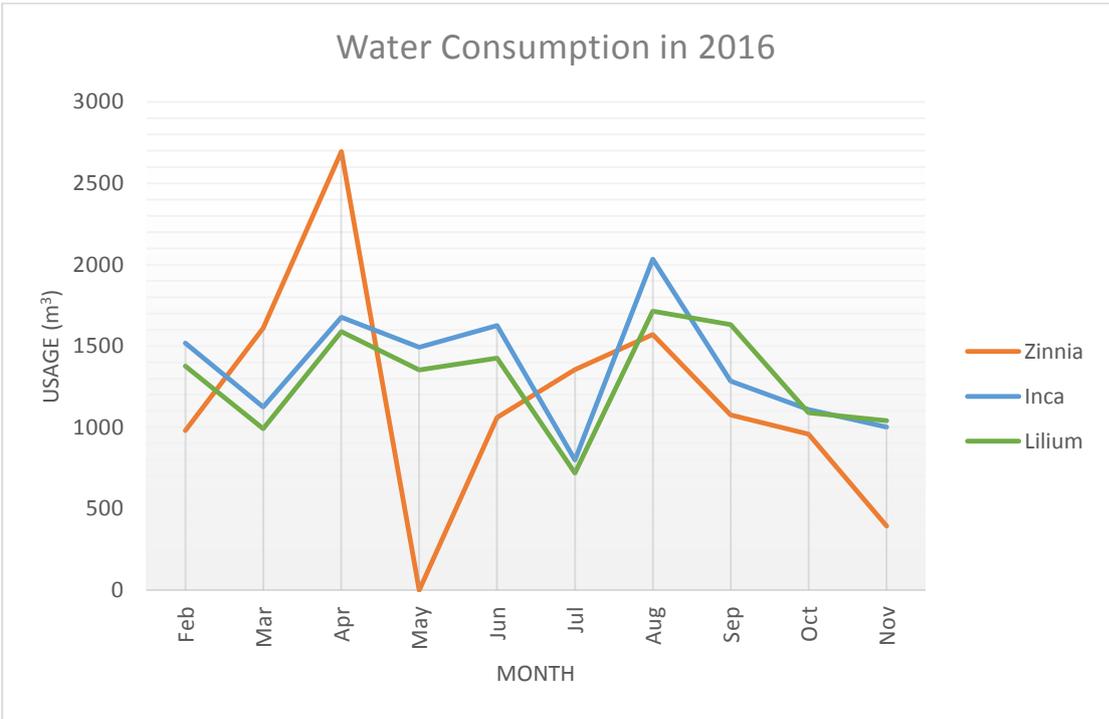


Figure 11: Water consumption in the three female residences in 2016

In 2016, the University of Pretoria saw a resurgence of the 'Fees Must Fall' movement in the early (January) and latter (September) parts of the year. The Hatfield and other satellite campuses were shut down with minimal admission. Classes were cancelled and students self-studied substantial amounts of work. This translated into more time being spent in residence. Nevertheless, 2016 follows the trend of 2014. Zinnia's water consumption has anomalous water meter readings for March, April and May. In the case of May, students were living in the residence but the records show a zero consumption of water.

Aggregated year-on-year electricity consumption increased by 3.16% from baseline in 2016. Water consumption reduced by 10.56% from baseline in the same year.

**4.3.2. Comparison of month-on-month readings for each residence**

The line charts indicating electricity consumption and line charts indicating water consumption, between February and November for 2014, 2015 and 2016 comparing each residences' monthly readings against its own are as follows:

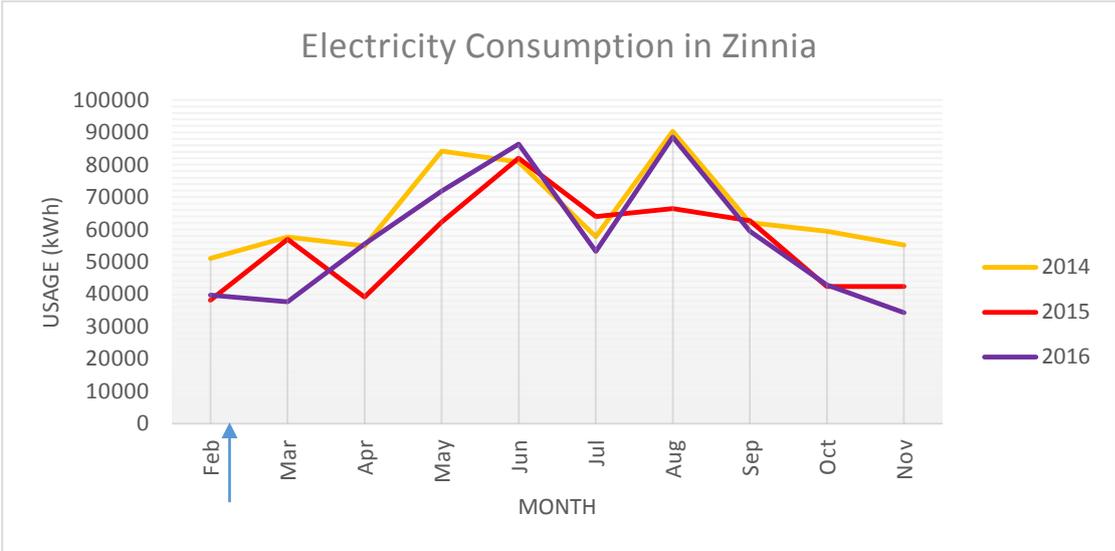
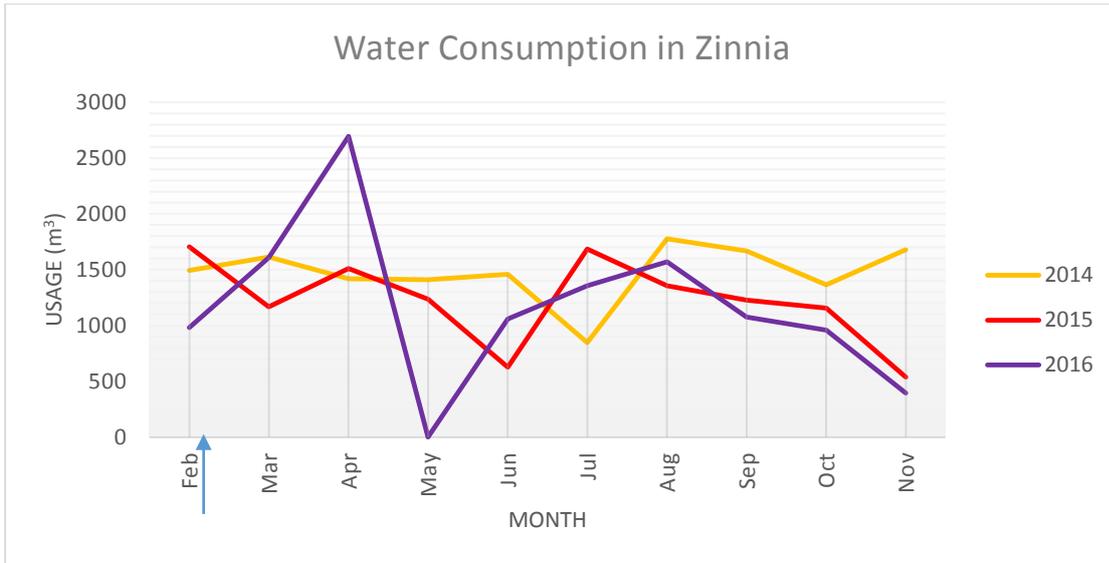
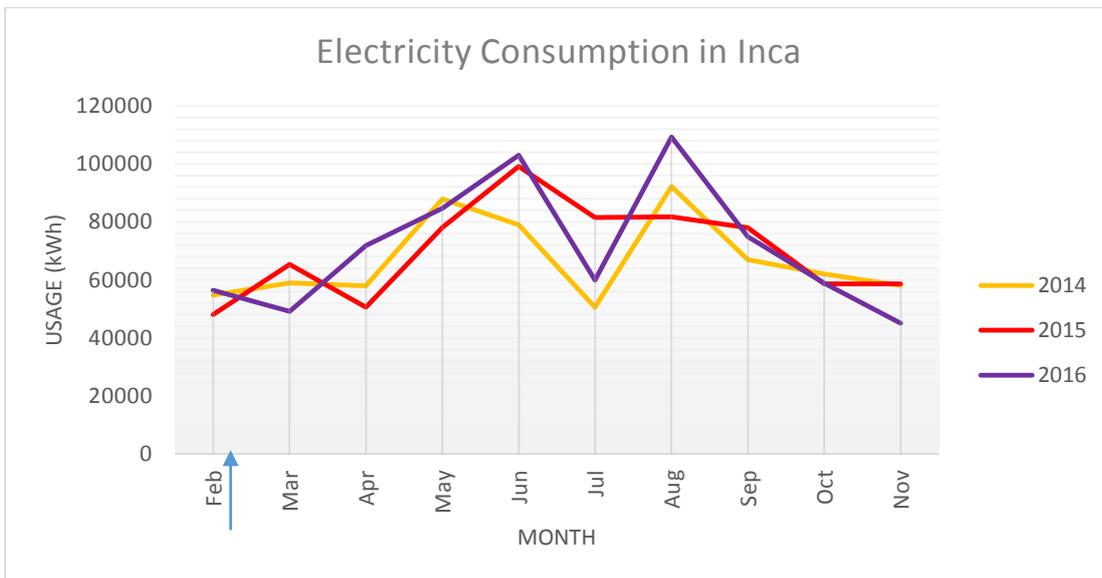


Figure 12: Electricity consumption in Zinnia for 2014, 2015 and 2016 (arrow indicates when posters were put up)



**Figure 13: Water consumption in Zinnia for 2014, 2015 and 2016 (arrow indicates when posters were put up)**

Individually, Zinnia reflects a year-on-year reduction in electricity use of 14.85% and 12.89% from the baseline for 2015 and 2016, respectively. Without considering the anomalous water consumption values of 2016, a year-on-year reduction of 17.12% and 20.58% from the baseline was achieved in Zinnia for 2015 and 2016, respectively.



**Figure 14: Electricity consumption in Inca for 2014, 2015 and 2016 (arrow indicates when posters were put up)**

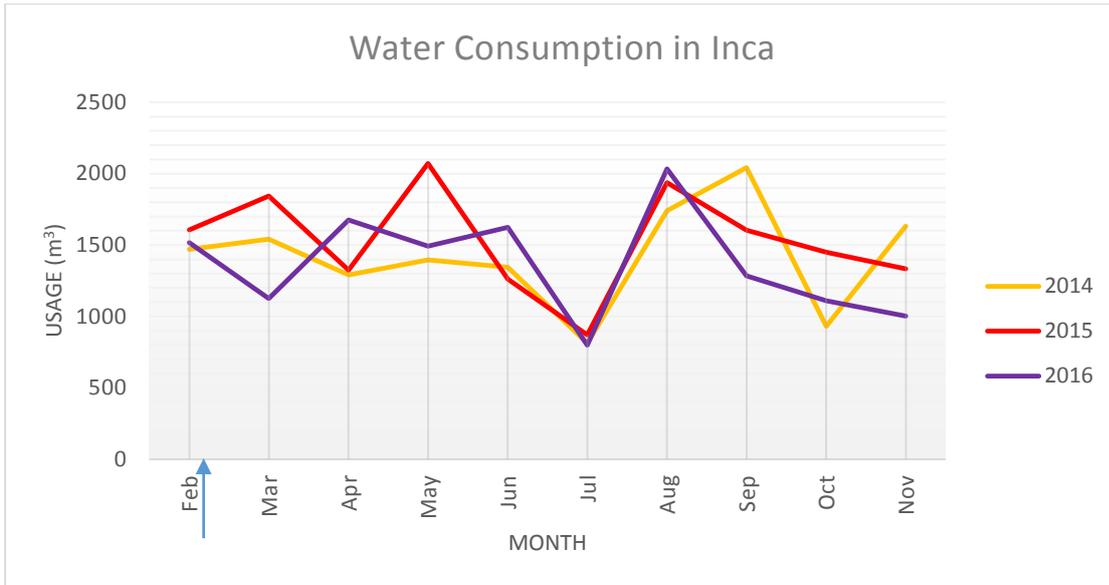


Figure 15: Water consumption in Inca for 2014, 2015 and 2016 (arrow indicates when posters were put up)

Inca's year-on-year electricity consumption increased by 4.69% and 6.67% from the baseline for 2015 and 2016, respectively. Year-on-year water consumption increased from baseline by 7.74% in 2015. However, in 2016, there was a 3.79% decrease from baseline.

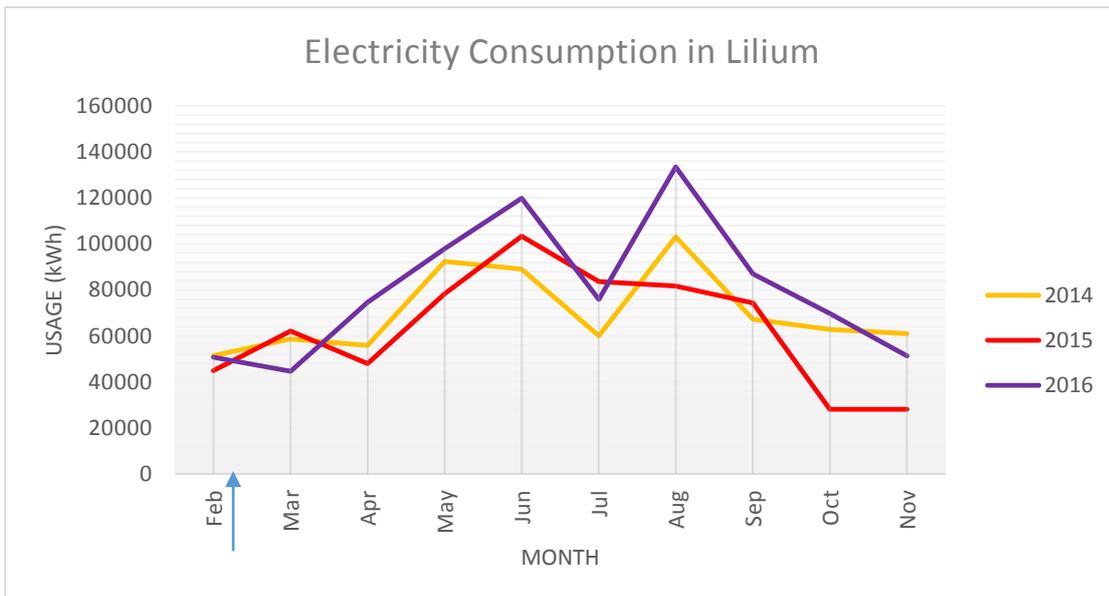


Figure 16: Electricity consumption in Lilium for 2014, 2015 and 2016 (arrow indicates when posters were put up)

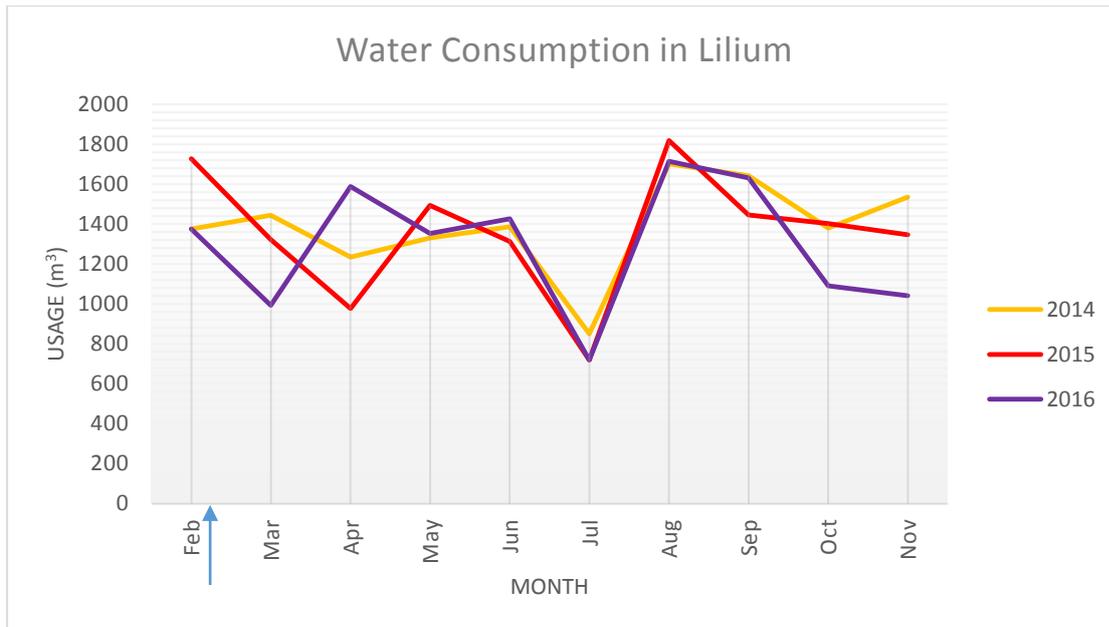


Figure 17: Water consumption in Lilium for 2014, 2015 and 2016 (arrow indicates when posters were put up)

Lilium’s year-on-year electricity consumption reduced by 9.84% from the baseline in 2015. However, it increased by 14.75% from baseline in 2016. Year-on-year water consumption decreased by 2.27% and 6.84% for 2015 and 2016 respectively.

#### 4.4. Statistical analysis

##### 4.4.1. Electrical consumption

The following are results from a ‘paired samples t-test’ run on meter readings for electrical consumption:

Table 7: Descriptive statistics for electricity consumption readings

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ZinniaElec2014	65352.00	10	14125.299	4466.812
	ZinniaElec2016	56928.80	10	19692.225	6227.228
Pair 2	IncaElec2014	66855.90	10	14446.008	4568.229
	IncaElec2016	71313.00	10	21916.933	6930.743
Pair 3	LiliumElec2014	70171.50	10	17839.182	5641.245
	LiliumElec2016	80523.70	10	29614.681	9364.984

**Table 8: Inferential statistics for electricity consumption readings**

		Paired Samples Test							
		Paired Differences			95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	ZinniaElec2014 - ZinniaElec2016	8423.200	9128.433	2886.664	1893.112	14953.288	2.918	9	.017
Pair 2	IncaElec2014 - IncaElec2016	-4457.100	12014.276	3799.248	-13051.595	4137.395	-1.173	9	.271
Pair 3	LiliumElec2014 - LiliumElec2016	-10352.200	15498.783	4901.146	-21439.362	734.962	-2.112	9	.064

The results of Zinnia’s inferential statistics indicate that, on average, there was a significant reduction in Zinnia’s electricity consumption when the intervention was administered (2016), as compared to the baseline (2014);  $t(9) = 2.918$ ,  $p = 0.017$ . The results of Inca’s inferential statistics indicate that, on average, there was no significant reduction in Inca’s electricity consumption when the intervention was administered (2016, as) compared to the baseline (2014);  $t(9) = -1.173$ ,  $p = 0.271$ . The results of Lilium’s inferential statistics indicate that, on average, there was no significant reduction in Liliums’s electricity consumption when the intervention was administered (2016, as) compared to the baseline (2014);  $t(9) = -2.112$ ,  $p = 0.064$ .

#### 4.4.2. Water consumption

The following are results from a 'paired samples t-test' run on meter readings for water consumption:

**Table 9: Descriptive statistics for water consumption readings**

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ZinniaWater2014	1473.00	10	258.968	81.893
	ZinniaWater2016	1169.80	10	729.017	230.535
Pair 2	IncaWater2014	1420.60	10	362.903	114.760
	IncaWater2016	1366.70	10	369.832	116.951
Pair 3	LiliumWater2014	1388.30	10	236.569	74.810
	LiliumWater2016	1293.50	10	321.601	101.699

**Table 10: Inferential statistics for water consumption readings**

		Paired Samples Test							
		Paired Differences			95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	ZinniaWater2014 - ZinniaWater2016	303.200	787.881	249.150	-260.416	866.816	1.217	9	.255
Pair 2	IncaWater2014 - IncaWater2016	53.900	404.658	127.964	-235.575	343.375	.421	9	.683
Pair 3	LiliumWater2014 - LiliumWater2016	94.800	255.492	80.794	-87.968	277.568	1.173	9	.271

The results of Zinnia’s inferential statistics indicate that, on average, there was no significant reduction in Zinnia’s water consumption when the intervention was administered (2016), as compared to the baseline (2014);  $t(9) = 1.217$ ,  $p = 0.255$ . The results of Inca’s inferential statistics indicate that, on average, there was no significant reduction in Inca’s water consumption when the intervention was administered (2016, as) compared to the baseline (2014);  $t(9) = 0.421$ ,  $p = 0.683$ . The results of Lilium’s inferential statistics indicate that, on average, there was no significant reduction in Lilium’s water consumption when the intervention was administered (2016), as compared to the baseline (2014);  $t(9) = 1.173$ ,  $p = 0.271$ .

## 4.5. Focus group responses

Focus groups were conducted with residents from each of the three residences. The focus groups were conducted in October 2017, almost a year after the intervention was administered.

### 4.5.1. Inca focus group

The focus group with Inca was aimed at determining whether the posters in the other two residences indirectly affected the residents, as students are known to visit each other. The assumption is that when using the amenities, Inca residents would also be exposed to the posters. Another major reason was to determine whether Inca residents had an awareness of environmental sustainability, global warming and the state of water and electricity supply in South Africa. Ten participants were present for the session. The following questions were posed and the summary of the responses (in italicised text) are presented.

1. What is your understanding of environmental sustainability?  
*Keeping the environment clean [2 participants]; conserving the environment [1 participant].*
2. Do you think environmental sustainability is an important thing? (Follow-up: whichever answer they choose, participants should be asked to elaborate/justify.)  
*[Participants unanimously think its important] preserving for future generations; we live off the environment and we need it to survive; live healthier and longer; limited resources.*
3. Have you received prior education on environmental sustainability?  
*Saw TV shows [all participants]; NGO sessions [1 participant]; LO class [3 participant]; class trip to sewerage plant [1 participant]; University of Pretoria Tourism class [2 participants].*
4. What is your understanding of global warming?  
*It has to do with gases [1 participant]; the Earth is getting warmer due to pollution trapping heat [2 participants].*
5. What is the condition of the electricity supply situation in your area?  
*We face no power cuts but bills are high [4 participants]; a lot of illegal connections [6 participants]; daily power cuts [1 participant]; about a week without electricity [2 participants]; winter power cuts [2 participants]; power affected by bad weather [1 participant]; prepaid electricity expensive [4 participants].*
6. Are you aware of any problems that ESKOM is facing in the short- and long-term?  
*Poor coal quality [2 participants]; old stations [1 participant].*
7. In what way have you or fellow residents wasted electricity, if any?  
*Having the heater on the whole day [5 participants]; few items in the washing machine [8 participants]; drying clothing for a long time [2 participants]; lights in common areas are always on [3 participants].*
8. Did you see the posters on water and electricity conservation in Zinnia or Lilium? [new question for Inca only]  
*Zinnia laundry rooms and bathrooms [2 participants]*
9. What is the condition of water supply situation in your area?

*Sometimes we go for days without water [3 participants]; water supply is adequate but people are wasting it [1 participant]; we are affected by construction work but otherwise, water is adequate [1 participant].*

10. In what way have you or fellow residents wasted water, if any?

*They take long showers, some even an hour long [6 participants]; taps are left dripping [3 participants]; the bathtubs are used a lot [3 participants]; taps are not closed when teeth are brushed [1 participant].*

11. What do you think would be effective interventions to reduce water and electricity consumption?

*Advocacy with peers [4 participants]; begin a res culture that supports it [3 participants]; comparative feedback [8 participants]; inter-res competition [unanimous].*

12. How do you intend on playing your part in reducing your water and electricity consumption?

*Using the elevator less often [3 participants]; shower more and use the bathtubs less [1 participant]; switching off lights more [2 participants]; switching off appliances instead of leaving them on standby [1 participants]; close the tap when brushing teeth [1 participant]; switch off the heater [3 participants]; advocate for reduction in consumption [2 participants].*

The focus group with Inca residents made it clear that there is a need of awareness of consumption via feedback. A propensity to waste utilities was reported, with the rationale being 'I paid for it'. Some participants reported a lot of water use in extended showers, while others reported using the bathtub a lot. This helps explain why Inca's year-on-year consumption has increased from baseline in 2015 and 2016. Not a lot of areas of improvement in terms of electricity use were suggested.

#### **4.5.2. Lilium focus group**

The Lilium focus group was aimed at understanding the impact the intervention had on residents, even if it was not reflecting as statistically significant. This could be that knowledge was not informing behaviour, that the awareness was not sufficient, that not enough residents were practising conservation behaviour, that the behaviour was not being conducted at substantial enough levels, or that there is not much perceived behavioural control (more bathtubs than showers). This focus group was to help in the interpretation of the quantitative data. The following questions were posed and the summary of the responses (in italicised text) are presented.

1. What is your understanding of environmental sustainability?

*Maintaining the environment for future generations [3 participants]; using our natural resources in a responsible manner [1 participant]; recycling resources [2 participants].*

2. Do you think environmental sustainability is an important thing? (Follow-up: whichever answer they choose, participants should be asked to elaborate/justify.)

*[Participants unanimously think its important] we depend on our environment for day-to-day living.*

3. Have you received prior education on environmental sustainability?

*Saw TV shows [all participants]; high school lessons [8 participants].*

4. What is your understanding of global warming?  
*Depletion of ozone layer [4 participants]; consequence of pollution [2 participants]; ice cape melting, floods, release of methane into the atmosphere [3 participants].*
5. What is the condition of the electricity supply situation in your area?  
*Poverty and corruption result in many illegal connections [5 participants]; electricity prices are high [6 participants]; stable electricity supply [6 participants].*
6. Are you aware of any problems that ESKOM is facing in the short- and long-term?  
*Fossil fuels being used to generate electricity [3 participants]; municipalities owe Eskom a lot of money [3 participants]; Eskom had to shut one power plant [1 participant].*
7. In what way have you or fellow residents wasted electricity, if any?  
*Having the heater on the whole day [3 participants]; few items in the washing machine [8 participants]; keeping lights on in room due to fear of the dark [3 participants]; using the lifts to travel a floor or two [4 participants].*
8. How have the posters changed your behaviour with regards to the use of water and electricity?  
*Reduced electricity usage [5 participants]; reduced time in the shower [4 participants]; switch off the lights in the common areas [2 participants]; closing taps [6 participants]; switching off the heater [5 participants]; using the lifts less often [3 participants]; the poster made me feel guilty but with time I got used to them and thus I just ignore them [4 participants].*
9. What is the condition of water supply situation in your area?  
*We get water cuts but we are warned in advance [3 participants]; water supply is adequate but people are wasting it [1 participant]; we are affected by construction work but otherwise, water is adequate [1 participant]; we get water over the weekend only [2 participants].*
10. In what way have you or fellow residents wasted water, if any?  
*They turn on shower and do other things before showering [3 participants]; taps are left running [4 participants]; the bathtubs are used a lot [6 participants]; no sink plugs in washroom, making people run a lot of water [unanimous]; people run a full bath, and then another to 'rinse' themselves [5 participants] .*
11. What do you think would be effective interventions to reduce water and electricity consumption?  
*Awareness campaigns [3 participants]; convert washing machines to work on tokens and give residents a fixed number per month [8 participants]; comparative feedback [4 participants]; inter-res competition [unanimous].*
12. How do you intend on playing your part in reducing your water and electricity consumption?  
*Combining laundry with roommate [1 participant]; shower more and use the bathtub less [2 participants]; switching off lights more [2 participants]; close the tap when brushing teeth [3 participants].*

The Lilium focus group reflected a general indifference regarding the wasteful behaviour in residence. One participant commented how Zinnia was disciplined, with residents turning off lights when a space was not in use. Another commented how the posters were pulled down in some places. The responses given around use of heaters, observed and practised behaviour,

provided some clarity as to why the electricity consumption increased dramatically in 2016. This increase was biggest in the autumn/winter months.

#### 4.5.3. Zinnia focus group

The Zinnia focus group had the same purpose as the Liliun one. However, it was also conducted to understand why Zinnia performs better than the other residences in terms of aggregated consumption. This would provide an understanding of whether or not there is a pre-existing propensity towards ecologically sustainable consumption of water and electricity or the posters were successful in changing behaviour.

1. What is your understanding of environmental sustainability?  
*Maintaining the environment for future generations [6 participants].*
2. Do you think environmental sustainability is an important thing? (Follow-up: whichever answer they choose, participants should be asked to elaborate/justify.)  
*It is important, because our actions will affect us in the future [9 participants]; it is an exaggeration, as we will always have water [1 participant].*
3. Have you received prior education on environmental sustainability?  
*Saw TV shows [all participants]; high school lessons [all participants].*
4. What is your understanding of global warming?  
*Depletion of ozone layer [4 participants]; consequence of pollution [2 participants]; release of methane into the atmosphere [3 participants].*
5. What is the condition of the electricity supply situation in your area?  
*Use fire from burning wood because electricity is expensive [2 participants]; we can go for a week without electricity [3 participants]; poverty and corruption result in many illegal connections [5 participants]; electricity prices are high [6 participants]; stable electricity supply [5 participants]; people sell ESKOM vouchers cheaply (R100 for R1 000 units) [1 participant].*
6. Are you aware of any problems that ESKOM is facing in the short- and long-term?  
*Exporting electricity causes reduced local supply [2 participants]; municipalities owe Eskom a lot of money [5 participants].*
7. In what way have you or fellow residents wasted electricity, if any?  
*Having the heater on the whole day [3 participants]; few items in the washing machine [5 participants]; keeping lights on in room due to fear of the dark [2 participants]; leaving appliances on standby [3 participants].*
8. How have the posters changed your behaviour with regards to the use of water and electricity?  
*Feel guilt when I do not conform [8 participants]; they set a standard in res, especially with shower time [4 participants]; stopped taking showers [1 participant]; always closing dripping taps [2 participants].*
9. What is the condition of water supply situation in your area?  
*We get water from the river because there is no running water [2 participants]; water supply is adequate but people are wasting it [2 participants]; we are affected by construction work but otherwise, water is adequate [1 participant]; we get water delivered in trucks twice a week [1 participant]; people regard water as free, using fire hydrants to get water to play with or run carwashes [3 participant].*

10. In what way have you or fellow residents wasted water, if any?

*Wash hands a lot as I get sick a lot - I am a germiphobe [1 participant]; taps are left running [4 participants]; the bathtubs are used a lot [3 participants]; no sink plugs in washroom, making people run a lot of water [unanimous]; people run a full bath, and then another to 'rinse' themselves [2 participants].*

11. What do you think would be effective interventions to reduce water and electricity consumption?

*More showers than bathtubs [unanimous]; convert washing machines to work on tokens and give residents a fixed number per month [6 participants]; comparative feedback [unanimous]; inter-res competition [unanimous]; use posters in other residences as well [4 participants].*

12. How do you intend on playing your part in reducing your water and electricity consumption?

*Combining laundry with roommate [1 participant]; shower more and use the bathtub less [2 participants]; switching off lights more [2 participants]; close the tap when brushing teeth [3 participants].*

The Zinnia focus group indicated that the posters had a great impact on the residents. Participants indicated that the posters were still up and that they thought that it was actually residence policy, making them take them seriously. They added that the presence of the posters made people conscious of their consumption, especially because they were placed in places where consumption took place. The participants also indicated that feedback would assist, as they would then be able to understand their severity of their impact, which could possibly make them more conscious of their actions.

With Zinnia's reduction in water and electricity and the resident's indicating the impact of the posters in altering their behaviour, there is reason to assume that the poster intervention changed behaviour in certain residents, but not at the level that is statistically significant.

#### **4.6. Discussion**

The meter readings obtained showed a trend of consumption, with May, June, August and September being the months with the highest consumption of both water and electricity. July, where undergraduate students evacuate residences reflects reduced consumption for that reason.

Zinnia, one of the residences that received the passive intervention, reduced both its water and electricity consumption. The focus group indicated a pro-environmental culture within the residence. Although only the electricity consumption reflected a statistically significant reduction, the reduction as per the meter readings is significant in CO<sub>2</sub> and monetary terms. Liliun, the other residence that received the passive intervention increased in its electricity consumption, but reduced its water consumption. The focus group indicated an ecological

illiteracy or an indifference to utility consumption behaviour. Inca, the control, increased in its electricity consumption, but reduced its water consumption. The focus group indicated a desire to be more pro-environmental.

Meter reading for 2017, the year post the intervention, could not be obtained. This made it unfeasible to run a post-intervention analysis, to determine whether behaviour changes that may have occurred are persistent or not.

Water consumption seems to be the easier behaviour to change and have a greater impact, as there is much more a resident can do to affect it. While there are bathtubs, a resident can take a short shower. On the electricity consumption side, reported consumption was largely due to the use of heaters, washing machines/dryers and lighting. As these are residences, there is not much electricity use in cooking equipment, notwithstanding the use of microwaves.

The meter readings are released on a quarterly basis by the University's Department of Facilities Management. While prompts as an intervention is more efficacious if used in conjunction with feedback, this was not feasible. The release of the data also does not coincide with the University's academic year, making it difficult to use for residences. The inability to provide feedback was a limitation in this study.

The focus groups assisted in the interpretation of results, revealing levels of ecological literacy and behaviours. They also enabled a better understanding on the efficacy of the intervention, highlighting that some residents had adopted pro-environmental behaviour while others seemed to be indifferent. This study confirms the benefit for interventions being evaluated and possessing quantitative data to ensure that the qualitative data can be interpreted accurately. In addition, qualitative data informs on how improvements can be made in methodology.

#### **4.7. Conclusion**

The meter readings were accurate in reflecting consumption of utilities, but were affected by student protest action. In 2015, aggregated year-on-year electricity consumption reduced by 6.65% (134 673kWh) from baseline. Water consumption reduced by 4.08% from baseline in the same year. In 2016, aggregated year-on-year electricity consumption increased by 3.16% (63 861kWh) from baseline. Water consumption reduced by 10.56% from baseline in the same year.

Individually, Zinnia reduced electricity use by 14.85% (97 019kWh) and 12.89% (84 232kWh) from the baseline for 2015 and 2016, respectively. Water consumption was reduced by 17.12%

(2 522m<sup>3</sup>) and 20.58% (3 032m<sup>3</sup>) from the baseline for 2015 and 2016, respectively. Inca's electricity consumption increased by 4.69% (31 371kWh) and 6.67% (44 571kWh) from baseline for 2015 and 2016, respectively. Water consumption increased from baseline by 7.74% (1 100m<sup>3</sup>) in 2015. However, in 2016, there was a 3.79% (539m<sup>3</sup>) decrease from baseline. Liliium's electricity consumption reduced by 9.84% (69 025kWh) from baseline in 2015. However, it increased by 14.75% (103 522kWh) from baseline in 2016. Water consumption decreased by 2.27% (315m<sup>3</sup>) and 6.84% (949m<sup>3</sup>) for 2015 and 2016 respectively.

Inferential statistics indicated that the only statistically significant reduction in electricity consumption occurred at Zinnia. There was no statistically significant reduction in water consumption in any of the residences.

## **CHAPTER 5 - CONCLUSIONS AND RECOMMENDATIONS**

### **5.1. Introduction**

The study was aimed at determining if passive interventions could be utilised to reduce the water and electricity consumption of residence students. Prompts in the form of posters were put up in two residences, namely Liliun and Zinnia. Inca, a third residence, was kept as the control group. 2014 was used as a baseline, as the Fees Must Fall movement had not begun and it therefore reflects more accurately typical consumption quantities in the residences. 2016 was used as the intervention year. This chapter will summarise the key findings of the study by looking at each research question. Additionally, recommendations for further studies will be made.

### **5.2. Revisiting the sub-research questions**

#### **5.2.1. Sub-question 1: What is behaviour change and what interventions exist to bring about behaviour change?**

The international literature indicates that behaviour change is a change in what we say and do. There are models that provide a framework for behaviour change, as they provide precursors to behaviour. These precursors, if changed, can change the behaviour. Two models discussed are the Theory of Reasoned Action and the Theory of Planned Behaviour. Both indicate that it is behavioural intention that precedes behaviour, and attitude and subjective norms are precursors of behavioural intention. The difference between the two models is the inclusion of perceived behavioural control. For this study, enhancing perceived behavioural control was important, as when residence see the ease with which water and electricity conservation can be done, they would be more willing to participate in it.

The international literature highlighted five informative strategies that can be used to bring about behaviour change. These are information provision, commitment, goal setting, prompting and feedback. Of the five, prompting and feedback have been used as passive strategies in dormitories (Karlin *et al.*, 2014; Konis *et al.*, 2016; Petersen *et al.*, 2015; Petersen *et al.*, 2007; Sintov *et al.*, 2016; Sussman & Gifford, 2012). These have at times been used in conjunction with other strategies, to leverage the strengths of each. A strategy commonly coupled with these is incentives, which have been used mainly in dormitory competitions scenarios.

The literature makes it clear that passive interventions have been used in dormitories and have yielded good results. Prompts, with particular focus on visual ones, have been used to reduce water and electricity consumptions. Posters placed at the point of decision have modified the

behaviour of residents on whom the intervention was administered. Enhancing efficacy of visual prompts has also been highlighted, such as including pictures and framing messages positively.

Feedback has usually been used in conjunction with another intervention, as feedback assists participants track their progress or lack thereof. Its strengths are maximised when used with other strategies. Furthermore, it is suggested that the higher the frequency of the feedback, the better the result.

### **5.2.2. Sub-question 2: Did the passive intervention reduce water and electricity consumption in the residences?**

The literature provides for examples where passive interventions, namely prompting and feedback, have been used successfully to bring about behaviour change. The persistence of this behaviour change is not within the theoretical scope of this study.

Prompts, in the form of posters and banners, have been used successfully to increase staircase use (Allais, Bazoche & Teyssier, 2017; Kwak, Kremers, van Baak & Brug, 2007; Lewis & Eves, 2012; Olander, Eves & Puig-Ribera, 2008). Prompts have received mixed reviews regarding efficacy in promoting hand washing by healthcare professionals (Caris, Labuschagne, Dekker, Kramer, van Agtmael & Vandenbroucke-Grauls, 2017; Mackert, Lazard, Champlin, Liang, Mabry, Stroever, Guadagno & Watkins, 2014; Wearn, Bhoopatkar & Nakatsuji, 2015). Other successful areas of use have been used to improve food choices (Stöckli, Stämpfli, Messner & Brunner, 2016) and reducing the rates of haemolysed samples collected (Corkill, 2012). The idea suggested is that prompts, if designed properly and placed intelligently, can be effective to bring about behaviour change in various contexts.

This study's results indicated that prompts can be effective passive interventions. The results of this study showed a statistically significant reduction in electricity consumption at Zinnia;  $t(9) = 2.918$ ,  $p = 0.017$ . There was a reduction of 8 423 kWh year on year. Liliums's electricity consumption increased: her results are  $t(9) = -2.112$ ,  $p = 0.064$ . This was an increase of 4 457 kWh year on year. Inca, the control, increased in electricity consumption. Her results were  $t(9) = -1.173$ ,  $p = 0.271$ . This was a 10 352 kWh increase year on year.

Water consumption was reduced in all three residences. However, the reductions were not statistically significant. The results for Zinnia, Inca and Lilium are  $t(9) = 1.217$ ,  $p = 0.255$ ,  $t(9) = 0.421$ ,  $p = 0.683$  and  $t(9) = 1.173$ ,  $p = 0.271$ , respectively. These reductions in water consumption were 303.2, 53.9, 94.8 m<sup>3</sup> respectively.

The results indicate that the use of prompts alone may not be enough. As was observed from the focus groups, there are other factors at work in the consumption patterns of students. These include culture, pre-existing awareness pro-environmental behaviour and group dynamics.

### **5.3. Recommendations**

The main recommendation for future research is a pre- and post-intervention assessment of the subject's attitudes and ecological literacy. This will make it easier to determine if the intervention affected the attitudes or just built up ecological literacy, both of which are precursors to behaviour change.

Future studies should compare results to climate data. This will indicate if people are prone to display certain behaviour regardless of the weather or not. The consumption trends could be compared to mean temperatures to determine if consumption of utilities can be predicted by weather predictions or habit is the better predictor.

Another recommendation is to include feedback, as it has been proven that feedback is an effective intervention strategy. This study did not include feedback and the results indicate that utilising prompts alone may not be enough. This is one point that the focus groups also raised, as they wanted to be able to measure their progress.

An additional study recommendation is to use demographics such as gender to see whether prompts as interventions are more effective with females or with males. This study focused on female residences only. A comparison of performance of females as compared to male would be beneficial.

Another study could consider the effects of building design. Is the intervention more effective in high-rise buildings or double storey-buildings? Does the equipment in a building determine which intervention is more efficacious?

Future studies can look at implementing both passive and active interventions. Interventions are known to be more effective when used together. The efficacy of the intervention could be tested individually and collectively, and whether or not active interventions are more efficacious than passive ones.

Lastly, future studies can investigate the effect of changing the messages of the prompts or the media with which they are presented.

## LIST OF REFERENCES

- Abrahamse, W., Steg, L., Vlek, C. & Rothengatter, T. 2005. A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, 25(3):273-291.
- Abrahamse, W., Steg, L., Vlek, C. & Rothengatter, T. 2007. The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents. *Journal of Environmental Psychology*, 27(4):265-276.
- Aerts, D., Apostel, L., De Moor, B., Hellemans, S., Maex, E., Van Belle, H. & Van der Veken, J. 2007. *Worldviews: from fragmentation to integration*. Brussels: VUB Press. [Online] Available from: [www.vub.ac.be/CLEA/pub/books/worldviews.pdf](http://www.vub.ac.be/CLEA/pub/books/worldviews.pdf) [Accessed: 2015-07-19].
- Ajzen, I. 1988. *Attitudes, personality and behavior*. Milton Keynes: Open University Press.
- Ajzen, I. & Fishbein, M. 1980. *Understanding attitude and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.
- Albarracín, D., Johnson, B.T., Fishbein, M. & Muellerleile, P.a. 2001. Theories of reasoned action and planned behavior as models of condom use: a meta-analysis. *Psychological bulletin*, 127(1):142-161.
- Alex, G. & Pouris, A. 2016. A 20 year forecast of water usage in electricity generation for South Africa amidst water scarce conditions. *Renewable and Sustainable Energy Reviews*, 62:1106-1121.
- Allais, O., Bazoche, P. & Teyssier, S. 2017. Getting more people on the stairs: the impact of point-of-decision prompts. *Social Science & Medicine*, 192(Supplement C):18-27.
- Allport, G.W. 1935. Attitudes. In: Murchison, C. (ed.). *A handbook of social psychology*. New York: Russell & Russell.
- Arkes, H.R. & Blumer, C. 1985. The psychology of sunk cost. *Organizational Behavior and Human Decision Processes*, 35(1):124-140.
- Arto, I., Andreoni, V. & Rueda-Cantuche, J.M. 2016. Global use of water resources: a multiregional analysis of water use, water footprint and water trade balance. *Water Resources and Economics*, 15:1-14.
- Barnett, J. 2003. Security and climate change. *Global Environmental Change*, 13(1):7-17.
- Barnett, J. & Adger, W.N. 2007. Climate change, human security and violent conflict. *Political Geography*, 26(6):639-655.
- Becker, B. & Fischer, D. 2013. Promoting renewable electricity generation in emerging economies. *Energy Policy*, 56:446-455.
- Belinskij, A. & Kotzé, L.J. 2016. Obligations arising from the right to water in Finland and South Africa. *Aquatic Procedia*, 6:30-38.
- Bergquist, M. & Nilsson, A. 2016. I saw the sign: promoting energy conservation via normative prompts. *Journal of Environmental Psychology*, 46:23-31.

- Bjornerud, M. 1997. Gaia: gender and scientific representations of the Earth. *NWSA JOURNAL*, 9(3):89-106.
- Blignaut, J., Inglezi-Lotz, R. & Weiderman, J.P. 2015. Sectoral electricity elasticities in South Africa: before and after the supply crisis of 2008. *South African Journal of Science*, 111(9):1-8.
- Bohlmann, J., Bohlmann, H., Inglesi-Lotz, R. & van Heerden, J. 2016. An economy-wide evaluation of new power generation in South Africa: the case of Medupi and Kusile. *Energy Policy*, 97:450-460.
- Boudet, H.S., Flora, J.A. & Armel, K.C. 2016. Clustering household energy-saving behaviours by behavioural attribute. *Energy Policy*, 92:444-454.
- Capra, F. 1996. *The web of life: a new scientific understanding of living systems*. New York: Anchor Books.
- Caris, M.G., Labuschagne, H.A., Dekker, M., Kramer, M.H.H., van Agtmael, M.A. & Vandenbroucke-Grauls, C.M.J.E. 2017. Nudging to improve hand hygiene. *Journal of Hospital Infection*.
- Chapin, F.S., Power, M.E., Pickett, S.T.A., Freitag, A., Reynolds, J.A., Jackson, R.B., Lodge, D.M., Duke, C., Collins, S.L., Power, A.G. & Bartuska, A. 2011. Earth stewardship: science for action to sustain the human-earth system. *Ecosphere*, 2(8):1-20.
- Collins-Chobanian, S. 2001. A proposal for environmental labels: informing consumers of the real costs of consumption. *Journal of Social Philosophy*, 32(4):334-356.
- Corkill, D. 2012. Testing the effects of educational toilet posters: A novel way of reducing haemolysis of blood samples within ED. *Australasian Emergency Nursing Journal*, 15(1):31-36.
- Crocker, R. 2013. From access to excess: consumerism, 'compulsory' consumption and behaviour change. In: Crocker, R. & Lehmann, S. (eds.). *Motivating change : sustainable design and behaviour in the built environment*. London :: Routledge, Taylor & Francis Group.
- Cunningham, T.R., Galloway-Williams, N. & Geller, E.S. 2010. Protecting the planet and its people: how do interventions to promote environmental sustainability and occupational safety and health overlap? *Journal of Safety Research*, 41(5):407-416.
- De Nardo, M., Brooks, J.S., Klinsky, S. & Wilson, C. 2017. Social signals and sustainability: ambiguity about motivations can affect status perceptions of efficiency and curtailment behaviors. *Environment Systems and Decisions*, 37(2):184-197.
- DeNicola, E., Aburizaiza, O.S., Siddique, A., Khwaja, H. & Carpenter, D.O. 2015. Climate change and water scarcity: the case of Saudi Arabia. *Annals of Global Health*, 81(3):342-353.
- Department of Energy. 2014. *Energy price report 2014*. [Online] Available from: <http://www.energy.gov.za/files/media/explained/Energy-Price-Report-2014.pdf> [Accessed: 2017-02-02].
- Department of Energy. 2015. *Strategic plan 2015-2020*. [Online] Available from: <http://www.energy.gov.za/files/aboutus/DoE-Strategic-Plan-2015-2020.pdf> [Accessed: 2017-03-10].

Department of Energy. n.d. *Basic electricity: overview*. [Online] Available from: [http://www.energy.gov.za/files/electricity\\_frame.html](http://www.energy.gov.za/files/electricity_frame.html) [Accessed: 2016-11-23].

Department of Minerals and Energy. 2005. *Energy efficiency strategy of the Republic of South Africa (March 2005)*. [Online] Available from: [http://www.energy.gov.za/files/esources/electricity/ee\\_strategy\\_05.pdf](http://www.energy.gov.za/files/esources/electricity/ee_strategy_05.pdf) [Accessed: 2016-09-10].

Department of Water Affairs. 2004. *Overview of the South African water sector - chapter 1*. [Online] Available from: [https://www.dwa.gov.za/io/Docs/CMA/CMA\\_GB\\_Training\\_Manuals/gbtrainingmanualchapter1.pdf](https://www.dwa.gov.za/io/Docs/CMA/CMA_GB_Training_Manuals/gbtrainingmanualchapter1.pdf) [Accessed: 2016-11-12].

Du Plessis, C. 2009. *An approach to studying urban sustainability from within an ecological worldview*. Doctoral dissertation. University of Salford, UK.

Eagly, A.H. & Chaiken, S. 1993. *The psychology of attitudes*. Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

Eagly, A.H. & Chaiken, S. 2007. The advantages of an inclusive definition of attitude. *Social Cognition*, 25(5):582-602.

Eskom Holdings S.O.C. Ltd. 2006. *Coal Power*. [Online] Available from: [http://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Coal\\_Power.aspx](http://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Coal_Power.aspx) [Accessed: 2017-03-28].

Eskom Holdings S.O.C. Ltd. 2007. *Eskom annual report 2007*. [Online] Available from: [http://financialresults.co.za/2007/eskomar2007\\_fin/downloads/eskom\\_ar2007.pdf](http://financialresults.co.za/2007/eskomar2007_fin/downloads/eskom_ar2007.pdf) [Accessed: 2016-08-12].

Eskom Holdings S.O.C. Ltd. 2015a. *System Status Media Presentation (January 15, 2015)*. 2015a. [Online] Available from: [http://www.eskom.co.za/news/Documents/20150115CE\\_SystemStatusPresent.pdf](http://www.eskom.co.za/news/Documents/20150115CE_SystemStatusPresent.pdf) [Accessed: 2017-02-23].

Eskom Holdings S.O.C. Ltd. 2015b. *Understanding electricity*. [Online] Available from: [http://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Understanding\\_Electricity.aspx](http://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Understanding_Electricity.aspx) [Accessed: 2016-09-10].

Eskom Holdings S.O.C. Ltd. 2016a. *Generation plant mix*. [Online] Available from: <http://www.eskom.co.za/AboutElectricity/FactsFigures/Documents/GX0001GenPlantMixRev15.pdf> [Accessed: 2016-09-27].

Eskom Holdings S.O.C. Ltd. 2016b. *Integrated report*. [Online] Available from: [http://www.eskom.co.za/IR2016/Documents/Eskom\\_integrated\\_report\\_2016.pdf](http://www.eskom.co.za/IR2016/Documents/Eskom_integrated_report_2016.pdf) [Accessed: 2016-06-30].

Fischer, F., Zakar, R. & Zakar, M.Z. 2012. Climate change-induced water scarcity : a threat to human health. *A Research Journal of South Asian Studies*, 27(2):293-312.

Fishbein, M. & Ajzen, I. 1975. *Belief, attitude, intention, and behavior : an introduction to theory and research*. Reading, Mass.: Addison-Wesley Pub. Co.

Gardner, G.T. & Stern, P.C. 1996. *Environmental problems and human behavior*. Boston: Allyn and Bacon.

Gillan, D.A., Leland Jr, L.S., Davies, A.M. & Walsh, K. 2004. Reducing curbside waste volumes by promoting household composting. *Journal of Environmental Systems*, 30(4):317-332.

Goudie, A. 1986. *The human impact: on the natural environment*. 2 ed. Oxford: Basil Blackwell Ltd.

Gowdy, J.M. 2008. Behavioral economics and climate change policy. *Journal of Economic Behavior & Organization*, 68(3):632-644.

Hes, D. & Du Plessis, C. 2015. *Designing for hope: pathways to regenerative sustainability*. Abingdon, Oxon: Routledge.

Hofstra, N. 2011. Quantifying the impact of climate change on enteric waterborne pathogen concentrations in surface water. *Current Opinion in Environmental Sustainability*, 3(6):471-479.

Holstein, J.A. & Gubrium, J.F. 2002. Qualitative interviewing, life history, and narrative analysis. In: Weinberg, D. (ed.): Blackwell Publishers.

Huggett, R.J. 1997. *Environmental change: the evolving ecosphere*. London: Routledge.

Inglesi, R. & Pouris, A. 2010. Forecasting electricity demand in South Africa: a critique of Eskom's projections. *South African Journal of Science*, 106(1-2):50-53.

Intergovernmental Panel on Climate Change. 2007. *Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom: Cambridge University Press. [Online] Available from: [http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4\\_wg2\\_full\\_report.pdf](http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4_wg2_full_report.pdf) [Accessed: 2017-07-23].

Intergovernmental Panel on Climate Change. 2011. *Renewable energy sources and climate change mitigation*. United Kingdom: Cambridge University Press. [Online] Available from: [https://www.ipcc.ch/pdf/special-reports/srren/SRREN\\_Full\\_Report.pdf](https://www.ipcc.ch/pdf/special-reports/srren/SRREN_Full_Report.pdf) [Accessed: 2017-05-12].

Intergovernmental Panel on Climate Change. 2013. *Climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom: Cambridge University Press. [Online] Available from: [http://www.climatechange2013.org/images/report/WG1AR5\\_ALL\\_FINAL.pdf](http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf) [Accessed: 2017-07-01].

International Energy Agency. 2016a. *Energy and Air Pollution*. [Online] Available from: <https://www.iea.org/publications/freepublications/publication/WorldEnergyOutlookSpecialReport2016EnergyandAirPollution.pdf> [Accessed: 2017-05-09].

International Energy Agency. 2016b. *Key world energy statistics*. [Online] Available from: <https://www.iea.org/publications/freepublications/publication/KeyWorld2016.pdf> [Accessed: 2017-04-12].

Jiang, X. & Green, C. 2017. The impact on global greenhouse gas emissions of geographic shifts in global supply chains. *Ecological Economics*, 139(Supplement C):102-114.

Johnson, B.T., Boynton, M.H. & James, W. 2010. Putting attitudes in their place, behavioral prediction in the face of competing variables. In: Forgas, J.P., Cooper, J. & Crano, W.D. (eds.). *Attitudes and attitude change*. 12 ed. New York: Psychology Press.

- Jury, W.A. & Vaux, H.J. 2007. The emerging global water crisis: managing scarcity and conflict between water users. *Advances in Agronomy*, 95:1-76.
- Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D. & Stokols, D. 2014. Dimensions of conservation. *Environment and Behavior*, 46(4):423-452.
- Kazdin, A.E. 2001. *Behavior modification in applied settings*. 6 ed. London: Wadsworth/Thomson Learning.
- Konis, K., Orosz, M. & Sintov, N. 2016. A window into occupant-driven energy outcomes: leveraging sub-metering infrastructure to examine psychosocial factors driving long-term outcomes of short-term competition-based energy interventions. *Energy and Buildings*, 116:206-217.
- Kwak, L., Kremers, S.P.J., van Baak, M.A. & Brug, J. 2007. A poster-based intervention to promote stair use in blue- and white-collar worksites. *Preventive Medicine*, 45(2):177-181.
- Lewis, A.L. & Eves, F.F. 2012. Testing the theory underlying the success of point-of-choice prompts: a multi-component stair climbing intervention. *Psychology of Sport and Exercise*, 13(2):126-132.
- Lilley, D., Smalley, G., Bridgens, B., Wilson, G.T. & Balasundaram, K. 2016. Cosmetic obsolescence? User perceptions of new and artificially aged materials. *Materials & Design*, 101(Supplement C):355-365.
- Liu, J., Liu, Q. & Yang, H. 2016. Assessing water scarcity by simultaneously considering environmental flow requirements, water quantity, and water quality. *Ecological Indicators*, 60:434-441.
- Mackert, M., Lazard, A., Champlin, S., Liang, M.-C., Mabry, A., Stroever, S., Guadagno, M. & Watkins, L. 2014. "Take time. Save lives. Clean hands protect." A comparison of two hand hygiene health promotion posters. *American Journal of Infection Control*, 42(5):530-532.
- Maio, G.R. & Haddock, G. 2010. *The psychology of attitudes and attitude change*. London: SAGE.
- Martin, G. & Pear, J. 1992. *Behaviour modification: what it is and how to do it*. 4th ed. New Jersey: Englewood Cliffs.
- Meadows, D.H., Meadows, D.L. & Randers, J. 1992. *Beyond the limits: confronting global collapse, envisioning a sustainable future*. Post Mills, Vt.: Chelsea Green Pub. Co.
- Mikulas, W.L. 1972. *Behavior modification: an overview*. New York: Harper & Row.
- Miltenberger, R. 2012. *Behavior modification: principles and procedures*. 5th ed. Australia: Wadsworth Cengage Learning.
- Mukheibir, P. 2010. Water access, water scarcity, and climate change. *Environmental Management*, 45(5):1027-1039.
- Nordås, R. & Gleditsch, N.P. 2015. Climate change and conflict. *Competition and Conflicts on Resource Use*, 26:21-38.
- Olander, E.K., Eves, F.F. & Puig-Ribera, A. 2008. Promoting stair climbing: stair-riser banners are better than posters... sometimes. *Preventive Medicine*, 46(4):308-310.

Omoogun, A.C., Egbonyi, E.E. & Onnoghen, U.N. 2016. From environmental awareness to environmental responsibility: towards a stewardship curriculum. *Journal of Educational Issues*, 2(2):60-72.

Organization of Oil Producing Countries. 2017. *OPEC and the environment*. [Online] Available from: [http://www.opec.org/opec\\_web/en/press\\_room/315.htm](http://www.opec.org/opec_web/en/press_room/315.htm) [Accessed: 2017-01-07].

Orr, D.W. 1994. *Earth in mind: on education, environment, and the human prospect*. Washington DC: Island Press.

Oxford English Dictionary. n.d. "consumerism, n.". *Oxford English Dictionary*. Oxford University Press. [Online] Available from: <http://www.oed.com/view/Entry/39979?redirectedFrom=consumerism> [Accessed: 2017-06-23].

Petersen, J.E., Frantz, C.M., Shammin, M.R., Yanisch, T.M., Tincknell, E. & Myers, N. 2015. Electricity and water conservation on college and university campuses in response to national competitions among dormitories: quantifying relationships between behavior, conservation strategies and psychological metrics. *PLoS ONE*, 10(12):1-41.

Petersen, J.E., Shunturov, V., Janda, K., Platt, G. & Weinberger, K. 2007. Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. *International Journal of Sustainability in Higher Education*, 8(1):16-33.

Pronyk, P.M., Muniz, M., Nemser, B., Somers, M.-A., McClellan, L., Palm, C.A., Huynh, U.K., Amor, Y.B., Begashaw, B., McArthur, J.W., Niang, A., Sachs, S.E., Singh, P., Teklehaimanot, A. & Sachs, J.D. 2012. The effect of an integrated multisector model for achieving the millennium development goals and improving child survival in rural sub-Saharan Africa: a non-randomised controlled assessment. *The Lancet*, 379(9832):2179-2188.

Reuveny, R. 2007. Climate change-induced migration and violent conflict. *Political Geography*, 26(6):656-673.

Rockström, J., Steffan, W., Noone, K., Persson, A., Chapin, F.S.I., Lambin, E., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Kalberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J. 2009a. Planetary boundaries: exploring the safe operating space for humanity. *Ecology and Society*, 14(2):32.

Rockström, J., Steffan, W., Noone, K., Persson, A., Chapin, F.S.I., Lambin, E., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Kalberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J. 2009b. A safe operating space for humanity. *Nature*, 461(7263):472.

Sale, P.F. 2011. *Our dying planet: an ecologist's view of the crisis we face*. Berkeley: University of California Press.

Santiago Ortiz-Correa, J., Resende Filho, M. & Dinar, A. 2016. Impact of access to water and sanitation services on educational attainment. *Water Resources and Economics*, 14:31-43.

Sebitosi, A.B. 2008. Energy efficiency, security of supply and the environment in South Africa: moving beyond the strategy documents. *Energy*, 33(11):1591-1596.

Sebitosi, A.B. & Pillay, P. 2008. Renewable energy and the environment in South Africa: a way forward. *Energy Policy*, 36(9):3312-3316.

Sheldon, B. 1982. *Behaviour modification: theory, practice, and philosophy*. New York: Tavistock Publications.

Sintov, N., Dux, E., Tran, A. & Orosz, M. 2016. What goes on behind closed doors?: How college dormitory residents change to save energy during a competition-based energy reduction intervention. *International Journal of Sustainability in Higher Education*, 17(4):451-470.

Smuts, J.C. 1987. *Holism and evolution*. Cape Town: N & S.

South African Weather Service. 2017. *How are the dates of the four seasons worked out?* [Online] Available from: <http://www.weathersa.co.za/learning/weather-questions/82-how-are-the-dates-of-the-four-seasons-worked-out> [Accessed: 2017-10-25].

Steg, L., Berg, A.E.v.d. & De Groot, J.I.M. 2013. *Environmental psychology: an introduction*. Oxford: BPS Blackwell.

Steg, L. & Vlek, C. 2009. Encouraging pro-environmental behaviour: an integrative review and research agenda. *Journal of Environmental Psychology*, 29(3):309-317.

Stöckli, S., Stämpfli, A.E., Messner, C. & Brunner, T.A. 2016. An (un)healthy poster: when environmental cues affect consumers' food choices at vending machines. *Appetite*, 96(Supplement C):368-374.

Strauss, A. & Corbin, J. 1998. *Basics of qualitative research: techniques and procedures for developing grounded theory*. 2 ed. Los Angeles: SAGE.

Subudhi, A.W., Askew, E.W. & Luetkemeier, M.J. 2005. Dehydration. In: Caballero, B. (ed.). *Encyclopedia of Human Nutrition (Second Edition)*. Oxford: Elsevier.

Sussman, R. & Gifford, R. 2012. Please turn off the lights: the effectiveness of visual prompts. *Applied Ergonomics*, 43(3):596-603.

Tetlow, R.M., Beaman, C.P., Elmualim, A.A. & Couling, K. 2014. Simple prompts reduce inadvertent energy consumption from lighting in office buildings. *Building and Environment*, 81:234-242.

Thopil, G.A. & Pouris, A. 2010. An overview of the electricity externality analysis in South Africa within the international context. *South African Journal of Science*, 106(11-12):1-6.

United Nations, Department of Economic and Social Affairs, Population Division. 2015. *World population prospects: the 2015 revision, key findings and advance tables*. [Online] Available from: [https://esa.un.org/unpd/wpp/Publications/Files/Key\\_Findings\\_WPP\\_2015.pdf](https://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf) [Accessed: 2016-11-12].

United Nations, Department of Public Information, Web Services Section. 2016. *The sustainable development agenda*. [Online] Available from: <http://www.un.org/sustainabledevelopment/development-agenda/> [Accessed: 2017-10-25].

United Nations, World Commission on Environment and Development,. 1987. *Report of the World Commission on Environment and Development: our common future*. [Online] Available from: <http://www.un-documents.net/our-common-future.pdf> [Accessed: 2015-06-10].

- Wearn, A., Bhoopatkar, H. & Nakatsuji, M. 2015. Evaluation of the effect of hand hygiene reminder signs on the use of antimicrobial hand gel in a clinical skills center. *Journal of Infection and Public Health*, 8(5):425-431.
- Weiss, E.B. 1992. In fairness to future generations and sustainable development. *Am. UJ Int'l L. & Pol'y*, 8:19.
- Winkler, H. 2007. Energy policies for sustainable development in South Africa. *Energy for Sustainable Development*, 11(1):26-34.
- World Health Organization. 2001. *Water-related diseases: malnutrition*. [Online] Available from: [http://www.who.int/water\\_sanitation\\_health/diseases-risks/diseases/malnutrition/en/](http://www.who.int/water_sanitation_health/diseases-risks/diseases/malnutrition/en/) [Accessed: 2017-06-16].
- World Health Organization. 2016. *Drinking water*. [Online] Available from: <http://www.who.int/mediacentre/factsheets/fs391/en/> [Accessed: 2017-06-16].
- World Health Organization. 2017. *Millennium development goals (MDGs)*. [Online] Available from: [http://www.who.int/topics/millennium\\_development\\_goals/about/en/](http://www.who.int/topics/millennium_development_goals/about/en/) [Accessed: 2017-06-27].
- Wu, X., Lu, Y., Zhou, S., Chen, L. & Xu, B. 2016. Impact of climate change on human infectious diseases: empirical evidence and human adaptation. *Environment International*, 86:14-23.
- Zerboni, A., Mori, L., Bosi, G., Buldrini, F., Bernasconi, A., Gatto, M.C. & Mercuri, A.M. 2017. Domestic firing activities and fuel consumption in a Saharan oasis: micromorphological and archaeobotanical evidence from the Garamantian site of Fewet (Central Sahara, SW Libya). *Journal of Arid Environments*, 144:123-138.
- Zheng, X., Wang, C., Cai, W., Kummu, M. & Varis, O. 2016. The vulnerability of thermoelectric power generation to water scarcity in China: current status and future scenarios for power planning and climate change. *Applied Energy*, 171:444-455.

# APPENDICES

## Appendix A

The following are the posters that were put up at Lilium. Those put up at Zinnia were the same, except for the change of the name in the footer.



### APPLIANCES

Please **switch off all appliances** when you are done using them: standby mode also consumes electricity.



Lilium Residence  
Electricity conservation



### BATH TUB

80¢ per bath

Please **do not** fill the water to the brim: use only as much water as you need.



Lilium Residence  
Water conservation



### BATH TUB

80¢ per bath

Please consider taking a **shower instead**: by showering you can use half the water of your bath.



Lilium Residence  
Water conservation



### HAND BASIN

6¢ per minute

Please **close the tap** tightly after use.



Lilium Residence  
Water conservation

## PLAY YOUR PART

Please help save water

### HAND BASIN

6ℓ per minute

Please **report** leaking/malfunctioning taps immediately.



Lilium Residence  
Water conservation

## PLAY YOUR PART

Please help save water

### HAND BASIN

6ℓ per minute

Please **close the tap** while brushing your teeth or washing, and open it only when rinsing, or **use a cup**.



Lilium Residence  
Water conservation

## PLAY YOUR PART

Please help save electricity

### LIGHTS

Please **turn off the light(s)** when you leave a room.



Lilium Residence  
Electricity conservation

## PLAY YOUR PART

Please help save water

### SHOWER

10ℓ per minute

Please **close water after soaping up** and turn it back on to rinse.



Lilium Residence  
Water conservation

**PLAY YOUR PART**  
Please help save water

**SHOWER**

10¢ per minute

Please take a shorter **5 minute** shower.



Lilium Residence  
Water conservation

**PLAY YOUR PART**  
Please help save water

**SHOWER**

10¢ per minute

Please **do not pre-steam** the shower: it wastes water and electricity.



Lilium Residence  
Water conservation

**PLAY YOUR PART**  
Please help save water

**TOILET**

13¢ per flush

Please do not use the toilet as a waste bin: **use the bin** provided instead.



Lilium Residence  
Water conservation

**PLAY YOUR PART**  
Please help save water

**TOILET**

13¢ per flush

Do not flush anything but **toilet paper**.



Lilium Residence  
Water conservation

**PLAY YOUR PART**  
Please help save water

**TOILET**

13ℓ per flush

Please **report** any leaking/malfunctioning toilets immediately.



**Lilium Residence**  
*Water conservation*

**PLAY YOUR PART**  
Please help save water

**WASHING MACHINE**

50 – 150ℓ per wash cycle

Please try to **wash full loads only**: you can combine loads with a friend or wait for your own dirty laundry to be a full load.



**Lilium Residence**  
*Water conservation*

## Appendix B

The following are the questions prepared for the focus groups:

### **Questions for focus groups**

*The following questions will be asked at the focus groups. Depending on the intervention(s), some of them might be omitted where they are not applicable.*

1. What is your understanding of environmental sustainability?
2. Do you think environmental sustainability is an important thing? (Follow-up: whichever answer they choose, participants should be asked to elaborate/justify.)
3. Have you received prior education on environmental sustainability?
4. What is your understanding of global warming?
5. What is the condition of the electricity supply situation in your area?
6. Are you aware of any problems that ESKOM is facing in the short- and long-term?
7. In what way have you or fellow residents wasted electricity, if any?
8. How have the posters changed your behaviour with regards to the use of water and electricity?
9. What is the condition of water supply situation in your area?
10. In what way have you or fellow residents wasted water, if any?
11. What do you think would be effective interventions to reduce water and electricity consumption?
12. How do you intend on playing your part in reducing your water and electricity consumption?